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ABSTRACT

A watershed is an area of land where water is drained ultimately to a particular watercourse or body of water. This curriculum guide acts as a comprehensive resource for educators at all levels to explore the many facets of watersheds for New York City. The guide investigates all the dynamics of watershed education, exploring the environmental and cultural dynamics of water, tracing it from a tiny spring in the mountain to a faucet in Brooklyn, New York. It includes a wide variety of activities as well as information sheets on terminology and issues on the subject of water. Each chapter incorporates suggestions for classroom assessment tools and follow-up projects for students. Major sections include hydrology, geology, ecology, pollution, land development, watershed technology, and conservation. Activities are listed by grade level (K-12) and subject area (subjects are primarily focused on the sciences and social studies, but also include such areas as art, economics, health, and mathematics). (AIM)

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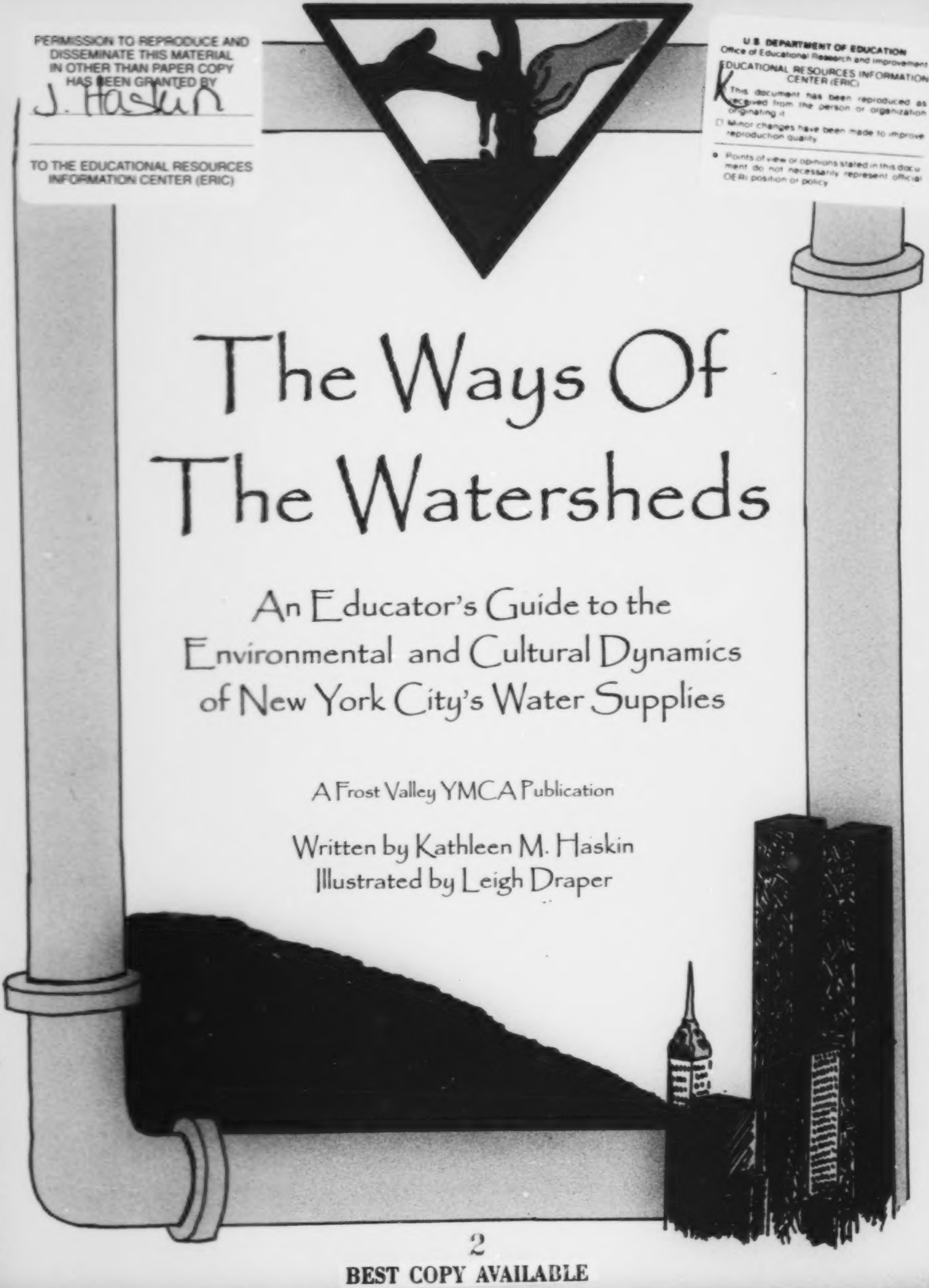

The Ways Of The Watersheds

An Educator's Guide to the Environmental and Cultural Dynamics of New York City's Water Supplies

A Frost Valley YMCA Publication

Written by Kathleen M. Haskin
Illustrated by Leigh Draper

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The Ways Of The Watersheds

An Educator's Guide to the Environmental and Cultural Dynamics of New York City's Water Supplies

A Frost Valley YMCA Publication

Written by Kathleen M. Haskin

Preface by D. Halbe Brown
Foreword by John Haskin

Illustrated by Leigh Draper

Funded by
The Geraldine R. Dodge Foundation

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Our principal sources of information have been identified wherever utilized. The bibliographical information is provided under **Cited Resources**.

For Trevor

Acknowledgments

The development of these teaching materials has been generously supported by a grant from the Geraldine R. Dodge Foundation with additional funding provided by the Open Space Institute. These lesson plans reflect the commitment that the Frost Valley YMCA has toward the experiential foundations guiding the YMCA's environmental education and community-involvement programs.

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This guide and a multitude of other exciting projects are possible at Frost Valley due to the combined efforts of this YMCA's Support Staffs whose services keep the guests safe and comfortable, the Program Instructors whose tireless hours keep the students exploring and learning, the Administrative Directors whose guidance steers our efforts, and the Trustees whose visions keep us focused on our possiblities.

Preface

A Partner in Preservation

The Frost Valley YMCA has its early roots in the field of camping. Founded in 1885, Frost Valley has developed into a year-round facility offering meaningful opportunities to people of all ages through our summer camps, family and conference programs and environmental education center. Utilizing our 4,900 acre site located in the heart of the Catskill Forest Preserve, we embody our YMCA's mission with a strong commitment to programs that help individuals obtain their fullest potential in spirit, mind and body.

Through our programs and partnerships with literally hundreds of schools and communities in the Tri-State area, we strive to promote environmental values and lifestyle choices that encourage responsible citizenship. The principle goals of our educational programs are to enlighten individuals about the environmental and cultural problems our communities face and to help them learn how to use that knowledge in defining their roles as stewards of the earth.

Working in this direction, Frost Valley joined with the United States Geological Survey in 1983 in a nationwide study of acid deposition. Frost Valley's Biscuit Creek Watershed Project remains a key contributor of data and research for the United States Geological Survey's National Trends Network to this day. Partnering with this well established research group has allowed Frost Valley's environmental education program to remain current in water studies as well as open a whole new world of science to visiting school groups and individuals.

Frost Valley has also taken a lead in forest management and nitrogen studies as well as innovative energy saving concepts in our new construction projects. It is in leading by example that our YMCA works toward educating individuals about not only the environmental and cultural situations we face, but also the search for solutions. In 1987, Frost Valley dedicated its Resource Management Center, the first facility in New York State to process food waste through aerated-static composting. This state-of-the-art center composts up to three tons of food waste a week, turning scraps into nutrient-rich soil to be used in the attached organic greenhouse and gardens.

These examples of Frost Valley's partnerships and projects illustrate our educational mission in searching for solutions and turning the wasted energy of conflict into the productive energy of cooperation.

Located in the Neversink Watershed on land supplying New York City with its drinking water, the Frost Valley YMCA is deeply concerned with preserving the quality of this vital resource. The relationship between New York City and many Catskill communities has often been one of discord even though it is these very partnerships that present opportunities for everyone to work together in search of sound and sustainable results. As educators and members of an environmentally-conscious township, we are driven to teach groups and individuals about the many facets of the water that comes out of their faucets. In working toward this objective, the

Frost Valley YMCA is proud to present The Ways of the Watersheds: An Educator's Guide to the Environmental and Cultural Dynamics of New York City's Water Supplies. The aim of this guide is to enlighten students, educators and friends who are interested in the preservation of one of our area's most valuable resources, pure water.

Individuals exposed to a comprehensive view of the watersheds, including their environmental and cultural dynamics, can better comprehend the magnitude of the regions' situations. It is our hope that this understanding will in turn help people find realistic ways in which each person can become a positive force in finding the needed solutions.

It is easy to say that you believe in a cause. With this curriculum project, Frost Valley is striving to put these words into action. The dynamic subjects of watersheds and water turn us all into educators and students as we strive to preserve our natural resource through communication and cooperation.

This manual takes a closer look at the many dimensions of our watersheds, their problems and possible solutions. Water supply is not a local problem. It is regional, national and even global in scope. Our mission with this educational effort is to focus people's attention and let no one ever take a glass of water for granted again.

D. Halbe Brown
Executive Director
The Frost Valley YMCA

Foreword

Here at the Frost Valley YMCA, the Catskills' Neversink River passes directly in front of my house. On the mountain behind our house, springs leap from the hillsides and form innumerable streams that will eventually join the Neversink. April and May offer even greater opportunities to experience these gentle gatherings of water as melting winter snows find their way off the hillside into the valley and eventually the river bed. This accumulation of water, drops joining together into streams increasing in volume until they eventually create rivers flowing toward the ocean, *this* is the way of the watershed.

A watershed is an area of land where its water is drained ultimately to a particular watercourse or body of water. Think of how the roof of a building sheds rainwater and through the use of gutters, directs the water to one drainage point. Imagine this *roof* to be the Catskill Mountains and the *gutters* to be the waterways that eventually bring the water to the ocean.

One hundred years ago the water flowing in the Neversink would have found its way to the Delaware River and eventually to the Chesapeake Bay and the Atlantic Ocean. Today, through one of the most remarkable engineering feats of modern history, much of this water is diverted and captured in reservoirs. Then, through fantastic aqueduct systems, the water is delivered to millions of homes, schools and businesses many miles away. This unique harmony of natural and human-made systems provides the life waters for the millions of residents of the New York City region as well as several upstate New York communities. While tremendous benefit has been realized as a result of the development of the aqueducts, the politics and process of maintaining this enormous watershed diversion project has not come without a price. This price over the years has been economic, environmental as well as cultural misunderstandings. The water we share provides a thread that connects these upstate and downstate residents. Although the residents of the Catskill region and New York City are more then one hundred miles apart and vastly different in appearance, culture and pace of life, we share this vital resource. We must remember that this resource is a gift all of us are responsible to care for whether that be through protection or conservation.

Webster's dictionary notes that a watershed can also be a crucial dividing or turning point. Clean drinking water, a vital resource many of us in the developed world are fortunate enough to take for granted, has become the focus of tension between areas who share watersheds. If we are to solve these conflicts peacefully and productively, we must take the opportunity to develop a greater understanding of the natural processes of the watersheds as well as improve our strategies for conflict resolution.

This curriculum guide is a resource for the educator who would attempt to explore the many facets of New York City's watersheds. It was proposed and planned by a group of enthusiastic educators searching for a resource that investigates all of the dynamics of watershed education. From a tiny spring in the mountains to a faucet in Brooklyn, this is an exploration of both the environmental and the cultural dynamics of this vital resource. The guide includes a wide variety of activities as well as information sheets on current terminology and issues on the subjects of water. In addition, incorporated into each chapter are suggestions for classroom assessment tools as well as follow-up projects for eager students.

A wise teacher once noted that: In the end we will only protect what we love - we will only love what we understand - and we will only understand what we are taught. Use the information and activities in this book to help your students understand, love and protect the ways of the watersheds.

John Haskin
Associate Executive Director
The Frost Valley YMCA

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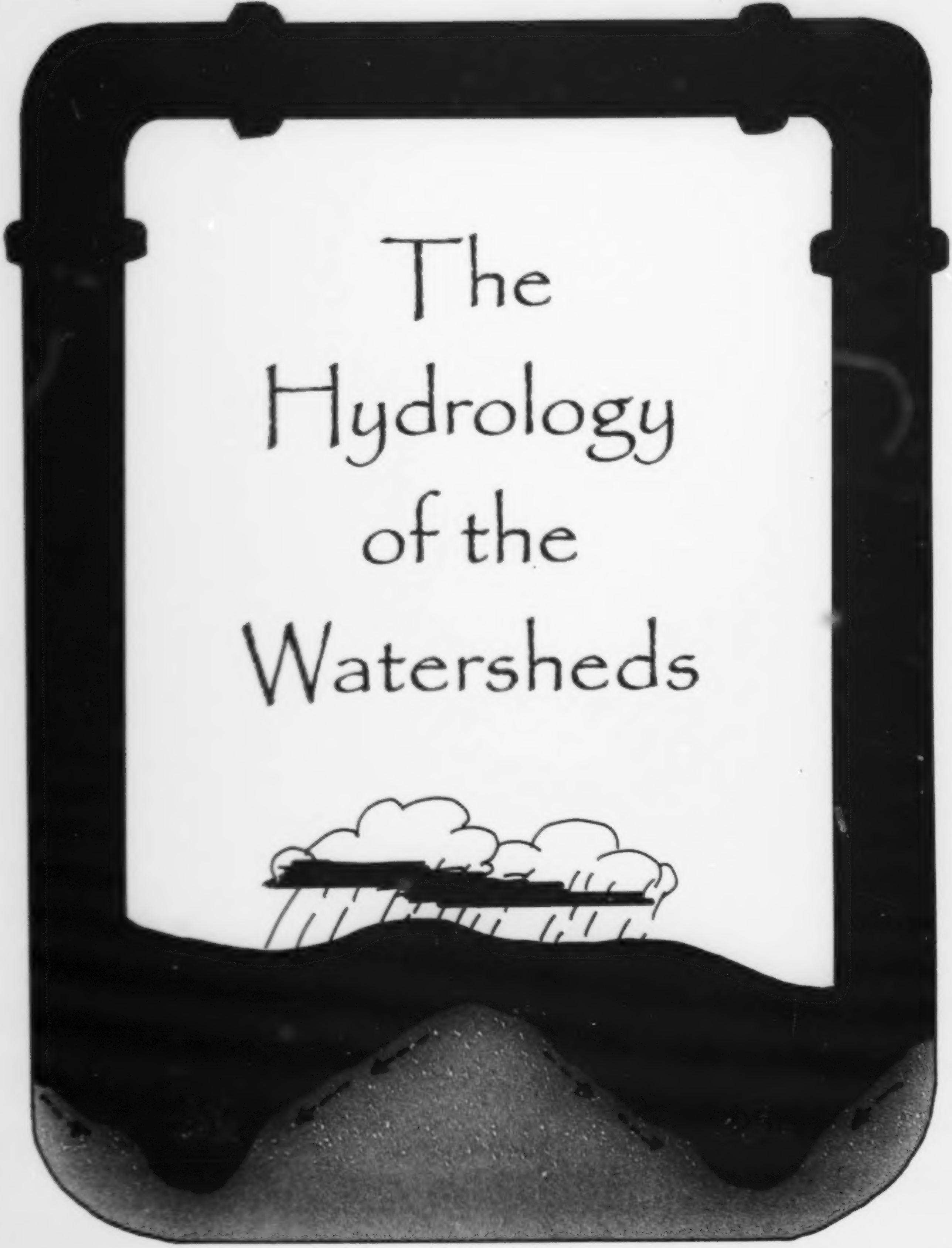
The Ways of the Watersheds Activities Guide

Activities listed by grade level and academic subjects

Activities	Grade Levels			Subjects														
	Elementary (K-5)	Middle (6-8)	Upper (9-12)	Art	Chemistry	Drama	Earth Science	Economics	General Science	Government	Health	History	Language Arts	Life Science	Math	Music	Physics	Social Studies
75% of the Earth	•	•	•		•		•							•	•			•
A Little Link in the Food Chain		•	•		•		•							•				•
Acid Rain Tag	•	•			•		•				•			•				•
Calculating Capacities		•	•				•								•			•
Camouflage!	•	•	•											•				
Can Nature Cope?	•	•	•		•		•	•			•			•	•			•
Cleaning-up Our Wastewater	•	•			•		•	•			•			•				•
Comparing Capacities	•	•					•								•			•
Considering Quantities	•	•	•				•		•					•	•			•
Copy Cat	•	•	•	•			•							•				•
Counting Raindrops	•	•					•		•						•			
Creature Creations	•	•		•			•						•	•				
Defining Soils	•	•					•							•				
Delivering A Drop	•	•					•					•		•				•
Drought Days	•	•					•							•	•			•
Earthlings	•	•					•							•				•
Finding Phosphorus		•	•		•		•							•				•
Gallons Per Minute		•	•				•							•	•		•	•
How Wet Is Your Home?	•	•	•					•							•			•
In A Bind	•	•	•				•				•			•				•
Is It Clean?		•	•		•		•				•			•				•
Is That Me?	•	•	•				•							•				
It All Adds Up	•	•			•		•				•			•	•			•
Line Up!		•	•	•			•							•	•			•
Making A Difference		•	•		•		•			•	•			•				•
Migration Mishaps	•	•					•							•				•
My View of Things	•	•	•	•			•							•				•
Mystery Soils	•	•					•						•	•				
NSP On Stage	•	•	•		•	•		•						•				•

Activities	Grade Levels			Subjects														
	Elementary (K-5)	Middle (6-8)	Upper (9-12)	Art	Chemistry	Drama	Earth Science	Economics	Gen. Science	Government	Health	History	Lang. Arts	Life Science	Math	Music	Physics	Social Studies
NY Upstaters & Downstaters	•	•	•					•		•		•						•
Oil Spill Emergency		•	•		•		•	•			•			•				•
One In A Billion		•	•		•									•	•			•
Patrolling Pollution	•	•	•		•		•	•			•			•	•			•
Picking A Place To Plant		•	•		•		•	•			•			•				
Plants Sweat!	•	•					•							•				
Pond and Stream Exploration	•	•	•		•		•							•	•			•
Pondering pH	•	•	•		•		•	•						•	•			•
Predacious Pesticides	•	•			•		•							•				•
Pump It Up		•	•		•		•				•							•
River Sticks	•	•	•				•						•			•		
Shower Timers	•						•								•			•
Soil Labyrinths	•	•			•		•											
Tap Tallies	•	•	•				•								•			•
The Choice Is Yours		•	•		•		•							•	•			•
The Clean Water Girl	•	•	•		•		•							•	•			•
The Great Debate	•	•					•							•				•
The Lay of the Land		•	•		•		•				•			•				•
The Power of a Drop	•						•								•			•
The Silent Water Waster	•	•	•		•		•								•			•
The Sounds of Water	•						•		•							•		
The Trouble With Turbidity		•	•		•		•				•			•				•
The Watershed Whodunit		•	•		•		•	•			•			•				•
The W. of the W. Stewardship	•	•	•		•		•			•	•			•				•
The Webs of Water	•				•		•		•		•			•				•
Too Much of a Good Thing		•	•		•		•							•				•
Washing Away	•	•			•		•				•			•				•
Water Carry	•	•	•		•		•				•			•				•
Water Rights Rivalries		•	•				•	•		•	•	•		•				•
Water Walk	•	•	•				•							•				•
Water Wisdom		•	•		•		•	•	•		•			•	•			•
Welcome to "Awayville"		•	•		•		•	•		•	•			•				•
Whose Water Is It?	•	•	•				•	•		•				•				•
Wise Water Usage	•	•	•				•							•	•			•

The Hydrology of the Watersheds



The Hydrology of the Watersheds

This section of our guide includes the following:

- information inserts - 🚰 - on the subjects of the characteristics of water and its cycles
- a variety of activities exploring topics in the properties of water, highlighting the distribution of the earth's water, the hydrological cycle and how these dynamics affect the ways of the watersheds

Introduction to the Water of Our World

🚰 *Properties and Characteristics of Water*

75% of the Earth
to illustrate the distribution of the water resources of our planet

Water Wisdom
to expose students to the many facets related to water

🚰 *Recycled*

🚰 *The Hydrologic Cycle*

The Sounds of Water
to introduce the steps of the water cycle

The Webs of Water
to demonstrate the inter-relatedness of the stages in the water cycle

Plants Sweat!
to illustrate the process of transpiration in plants

Counting Raindrops
to take a closer look at a specific step in the water cycle

The Clean Water Girl & The Solar Water Cleaner
to increase students' global awareness and illustrate how to use the water cycle in cleaning a sample of water

Assessment Tools

Class Follow-up Projects

The Water
Of Our World

"If there is magic on this planet, it is contained in water."
- Loren Eisley

Water - agua - vatten - mizu - voda - wasser - ujë - Water means different things to different people.

To a chemist, water is H_2O, a molecule composed of one oxygen and two hydrogen atoms.
To a biologist, water is nourishment necessary for all living organisms.
To an ecologist, water is a habitat hosting a world of interrelated species.
To townships and cities, water is a utility to be managed and sustained.
To a farmer, water is a necessity for strong and productive crops.
To a nuclear physicist, water is a coolant needed for safety.
To a firefighter, water is a useful tool for extinguishing flames.
To a municipal composter, water is a aerobic decomposition byproduct.
To a paper manufacturer, water is an ingredient in a product's recipe.
To a tanker captain, water is a means of transporting goods.
To a young child, water is a refreshing way to cool off on a hot summer day.
To many areas of the world, water is a focus of tension and political confrontations.
To all of us, water is life.

What makes water so very important to so many different people? In order to begin to answer that question, we must start by examining the chemical, physical and biological characteristics of the water in our world.

Properties and Characteristics of Water

Chemical Characteristics

Water has an interesting **molecular structure** consisting of one oxygen and two hydrogen atoms held together by chemical bonds. Each molecule is asymmetrical with each end holding an electrical charge. The dynamics of the strong chemical bonding of a water molecule account for its great dissolving property and for this reason water is sometimes referred to as the "universal solvent". Given enough time and proper conditions, water can dissolve just about any substance.

Physical Characteristics

Water is the only substance on earth that within the normal range of climatic conditions, can appear in all three of its **natural states**: liquid, solid (ice) and gas (water vapor). It is even possible to have all three forms at the same time, for example: rain, snow or hail, and steam before it condenses to form a cloud. It is this quality which allows for the water cycle, the process whereby the Earth's water is moved by the energy of the sun and the force of gravity through a cycle of evaporation, condensation, precipitation and accumulation.

Another notable property of water is its high **specific heat** or its ability to absorb heat without becoming extremely hot itself. One way to observe this characteristic is to heat an empty pan over a fire. The pan quickly becomes red hot and may start to burn. Place the same pan over the fire with water in it and the liquid will absorb some of the heat. The pan will again become hot but not as hot as before. The temperature of the water, even if it boils, will rise only a small amount compared to the temperature of the pan. It is water's high heat capacity that allows it to play an important role in affecting climatic conditions. This is evident in desert areas which lack water's moderating influence and exhibit very hot temperatures during the day and very cold temperatures at night.

Another interesting physical characteristic of water is its high **surface tension** or its ability to "pull itself together" or to cohere into a sphere as it drops from a tap for instance. This high surface tension plays an important role in both enabling water to support objects heavier than itself, such as an insect skating across the surface and also in the capillary movement of water in soil and through the bodies of plants and animals. In the study of water it is also noteworthy to explore this substance's latent heat, density, pH and electrical conductivity as well as its boiling and melting points.

Biological Characteristics

There are many organisms in this world that can exist without oxygen, but all living creatures need water in order to survive. Human beings, for example are between sixty-five and seventy percent water. Most of the plants that we use for food are between eighty-five and ninety percent water by weight.

Water is used for **life support** in a variety of capacities ranging from habitats to reproduction to animal body functions (i.e digest food, transport wastes, lubricate body joints, regulate temperature, and soften body tissues). It is clear that life as we know it could not exist on Earth without its most abundant and remarkable substance - water.

75% of the Earth

Grades: all grade levels
Objective: to illustrate the distribution of water resources on our planet
Subjects: Earth and Life Sciences, Chemistry, Math, Social Studies

Materials: One clear 10 gallon container, 5 gallons of water, three clear 5 gallon containers, one cup, one eyedropper, tablespoons, paper, pencils, calculators (optional)

Information:

"If all existing water could be spread evenly over a smooth sphere the size of the earth, it would cover the globe to a depth of 3,000 meters or almost 2 miles." - *Water: The Threatened Lifeline* by Sidney R. Jumper, Update, Fall 1992, National Geography Society

Water is a precious natural resource to us and probably our most limited one. Although 75% of the earth's surface is water, it is not all available for our use. Water exists throughout the planet in three forms: solid, liquid and vapor. The global distribution of water has been calculated to be:

97.2% = oceans
2% = ice caps and glaciers
.62% = ground water
.009% = freshwater lakes
.008% = inland seas and salt lakes
.001% = atmosphere
.0001% = rivers and streams

The following demonstration is designed to help students visualize the different distributions of water on earth.

Procedures:

1. To help the students visualize the global distribution of water, present a container with 5 gallons of water that represents all of the water on earth. As you talk about the location of water throughout the planet, remove the specified quantities into other containers.
2. 97.2% of all of the water on earth is in the oceans. This water contains dissolved solids, mostly salt. It can be used for transportation, however, it is unfit for drinking, washing, irrigating crops and industrial purposes. When this amount of water is removed from the total in the container, approximately 2 & 1/4 cups of the water remain.
3. Place the 2 & 1/4 cups of water into a smaller container. This amount represents the total amount of fresh water on our planet. A portion of this water is located in glaciers, ice caps, soils and the atmosphere and is thus not directly available for use by humans.
4. Place about 1/2 cup of the fresh water supply into the next container. This is the fresh water available to us though it is not evenly distributed throughout the world. Of this 1/2 cup of available water, we must consider that the water that is found in remote locations, trapped underground or polluted is not available for us to use. The remaining usable fresh water supply is about 5 drops!

5. Place 5 drops of the water into the final container. (Note: A metal pie pan in the bottom of the bucket makes a loud "ting" for a more dramatic effect.) Have the students name all of the ways in our lives today that we use and share these 5 drops of water.

Variations:

- Ask the students to calculate the volume of water for each specific category of global distribution using the percentages given and 10 gallons of water. Provide them with the following quantity: 1 gallon = 320 tablespoons. Examples of calculations would be:

  Total in tablespoons = 10 gallons x 320 tablespoons
  Percentage of oceans in tablespoons = 0.972 x Total in tablespoons

  With each of the calculations, have the students physically measure the amounts of water into different containers. By doing this, they will become even more familiar with the proportions they are computing.

- Using 100 marbles, have the students separate the marbles into piles representing the different water sources.

- As you discuss with your students related water conservation topics, explore the activities from the *Conserving the Quantities of the Watersheds* chapter of this guide.

Watershed Discussion Questions:

- Is water a renewable or non-renewable resource?
- From what type of freshwater supply does your drinking water come?
- How much water do you use every day at home or school?

Source: Adapted from *75% of the Earth Surface* in Linking Your Y with the World and *Info on Water* in Taking the World to Camp

Water Wisdom

Grades: middle and upper
Objective: to expose students to the many facets related to water
Subjects: All Sciences, Chemistry, Economics, Health, Math, Social Studies

Materials: paper and pencils, Water Wisdom trivia answer sheet

Information:

"Questions, not answers, stimulate the mind." - *Richard Paul*

Water is a complex, dynamic topic that we may integrate into every part of our curricula from the sciences to social studies, health, history and economics.

By informing students fully of the many different facets of water and its related issues, we are able to highlight and expand on many different aspects of the world around us. The following is a fun activity designed to help students explore and develop their current knowledge on the subject of water.

Procedures:

1. Water Wisdom is a trivia game with a twist. Begin by dividing the students into three or four equal teams. Supply each team with paper and pencil. Explain to the students that you will be asking the groups for the answers to a series of questions. For each of the questions, it is their job to create an answer that sounds convincing but is not actually correct.

2. Start with the example from the Water Wisdom Trivia Answer Sheet: Where is the greatest amount of freshwater found on earth? Have each group make up an answer and write it on a slip of paper. Collect the groups' answers and mix them together in a pile including a piece of paper with the correct answer (the polar ice caps).

3. Explain to the students that it is now their task to guess which answer is the correct one. Read the assortment of answers aloud to the students. After a short time for the students' decision-making, ask the groups for their votes. Give a point to each group that chooses the correct answer as well as a point to each group whose answer was chosen by another group. With this scoring, a group will receive points for the correct answers as well as for reasonable decoy answers.

4. After each correct answer is presented, take this opportunity to expand on the subject and facilitate a group discussion around the reasoning behind the true answer. For instance, after this example question, a discussion may follow on the locations and volume of the earth's current polar ice caps or the topic can be expanded to the overall distribution of fresh and salt water on earth.

Variation:

- Have a panel of "experts" (a group of students) answer the questions and have the groups guess which one is answering correctly.

Source: Adapted from a game presented by Michael P. Godfrey, 7th Grade Science Teacher, Eastwood Middle School, Pemberville, Ohio

Water Wisdom Trivia

Question / Answer Sheet

The Properties of Water

- What atoms from two colorless and odorless gases make up a molecule of water? (hydrogen & oxygen)
- What is the term for the amount of water vapor in the air? (humidity)
- At what temperature will water freeze? (32° F, 0° C)
- What is the term for the process in which water becomes vapor? (evaporation)

Water and Living Things

- On average, what percentage of the adult body is water? (65-70%)
- A person can live approximately one month without food. How long can a person survive without water? (approximately one week)
- What percentage of a living tree is water? (75%)
- Name two different reasons for which a living organism may need water. (habitat, reproduction, bathing, cooking, animal body functions, i.e. digest food, transport wastes, lubricate body joints, regulate temperature, keep tissues soft, etc.)

Distribution of the Earth's Water

- What is the total volume of water on the earth today in gallons? (370,000,000,000,000,000,000 gals)
- Where is the greatest amount of freshwater found on earth? (the polar ice caps)
- What is the term for an area of land that receives water from rainfall and snowfall and delivers it to streams, lakes and rivers? (a watershed)
- What is the term for water found in reservoirs under the earth's surface? (groundwater)

Water Conservation

- What uses 40% of your home's water? (the toilet tank)
- How many gallons of water does a fully open fire hydrant use per minute? (1,000 gals)
- How many gallons of water does a steady drip in a faucet waste in one day? (20 gals)
- How many gallons of water does the average American use in a day, including industrial uses? (2,000 gallons per person per day, 394 billion gallons used in US/day)

Water and Industry

- How many gallons of water does it take to make a copy of a Sunday newspaper? (150 gals)
- How many gallons of water does it take to produce the average domestic auto, including the tires? (100,000 gals)
- How many gallons of water does it take to process a meal of a quarter pound hamburger, an order of fries and a soft drink? (1,400 gals)

Water Pollution

- What is the term for the presence of harmful materials that could cause undesirable effects on the environment? (pollution)
- What is the term for rain or melting snow that flows over the ground and returns to streams sometimes carrying with it pollutants picked up from the air or land? (runoff)
- What is the term for the organic waste and wastewater that comes from homes, agricultural lands and businesses? (sewage)

Recycled

The glass of water you're about to drink
Deserves a second thought, I think,
For Avogadro*, oceans and those you follow
Are all involved in every swallow.

The molecules of water in a single glass
In number, at least five times, outclass
The glasses of water in stream and sea,
Or wherever else that water can be.

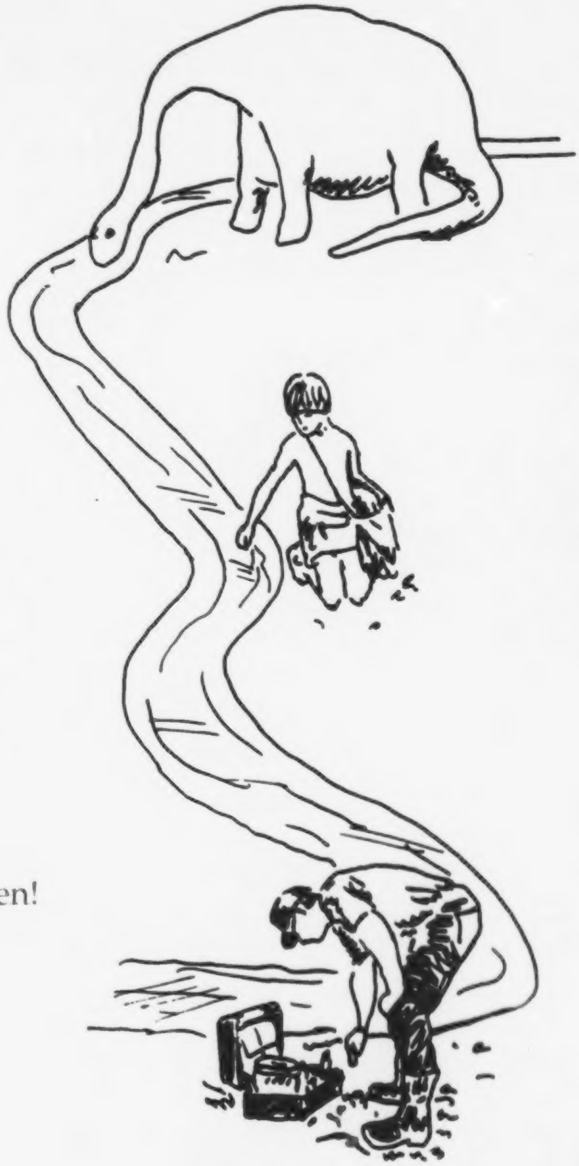
The water in you is between and betwixt,
And having traversed is thoroughly mixed,
So someone quenching a future thirst
Could easily drink what you drank first!

That water you are about to taste
No doubt represents a bit of the waste
From prehistoric beast and bird —
A notion you may find absurd.

The fountain spraying in the park
Could well spout bits of Joan of Arc,
or Adam, Eve, and all their kin;
You'd be surprised where your drink has been!

Just think! The water you cannot retain
Will some day hence return as rain,
Or be beheld as the purest dew.
Though long ago it passed through you!

— *Verne N. Rockcastle*



**Amedeo Avogadro was an Italian scientist (1776- 1856)*

The Hydrologic Cycle

It is often confusing for students to try to imagine that the water they are drinking today may have been part of a dinosaur's bath thousands of years ago. But this can be true. The amount of water on the planet is finite and is constantly circulating through the atmosphere and falling back down to the earth. This constant movement and changing nature of our water resources is described in a process called the hydrologic or water cycle.

As Figure 1 shows, the earth's water is constantly cycling from the oceans, through the atmosphere and over the land. The world's ocean, measuring 139 million square miles, contains approximately 317 million cubic miles of saltwater and covers nearly 75% of the planet's surface. It is there that sunlight and wind cause large amounts of water to **evaporate** into its gaseous state (vapor) and lift up into the atmosphere.

As the moist air reaches the cooler upper layers of the atmosphere, this water vapor **condenses** onto fine particles in the air such as dust, pollen grains or pollutants, and forms clouds. As the droplets in a cloud grow larger with additional moist air, they soon lose their buoyancy and fall to earth as **precipitation**. About 85% of the world's precipitation falls directly into the oceans.

The precipitation that falls on the land has a variety of courses it may take. Often the water falls to the land, runs across the surface of the soil (**runoff**) and then through waterways, ultimately returning to the oceans. The area of land that receives water from rain and snowfall and delivers it to a particular stream, lake or river is called a **watershed**. It is estimated that the total flow or runoff into the sea from the rivers flowing from the 48 contiguous states is about 13,986,440 gallons per second!

Besides flowing to the oceans as runoff, precipitation falling on land can also be **absorbed** by the plants and animals present or seep through the soil until it reaches an area where all the pores between the rocks and soil particles are filled with water. Water that reaches these saturation zones is called groundwater. The upper surface of the zone of saturation is known as the **water table**. The rate at which water seeps into the land surfaces depends greatly on the **porosity** of the soil materials. In very porous surfaces such as sand or gravel, 25 - 50 percent of the rain or snowmelt may seep into the ground. Clay surfaces, though they tend to limit infiltration and seepage, are porous enough to be capable of accepting a larger total volume of water than some sand surfaces. Seepage into the ground is also dependent upon the amount of plant growth, evaporation or frozen soil present as well as being greatly influenced by the season of year.

Underground water will at times reach the earth's surface again as a spring, seep or stream somewhere in the watershed. This surface water and water in the soil is warmed by the sun and evaporated into vapor. Water in plants may become vapor through a process called **transpiration**. The term **evapotranspiration** is used to describe the combined processes of evaporation of surface water from the soil and transpiration from plants. With liquid turning to vapor once again, the cycle begins once more with a continuous process of water circulating between the earth, plants and animals and the atmosphere.

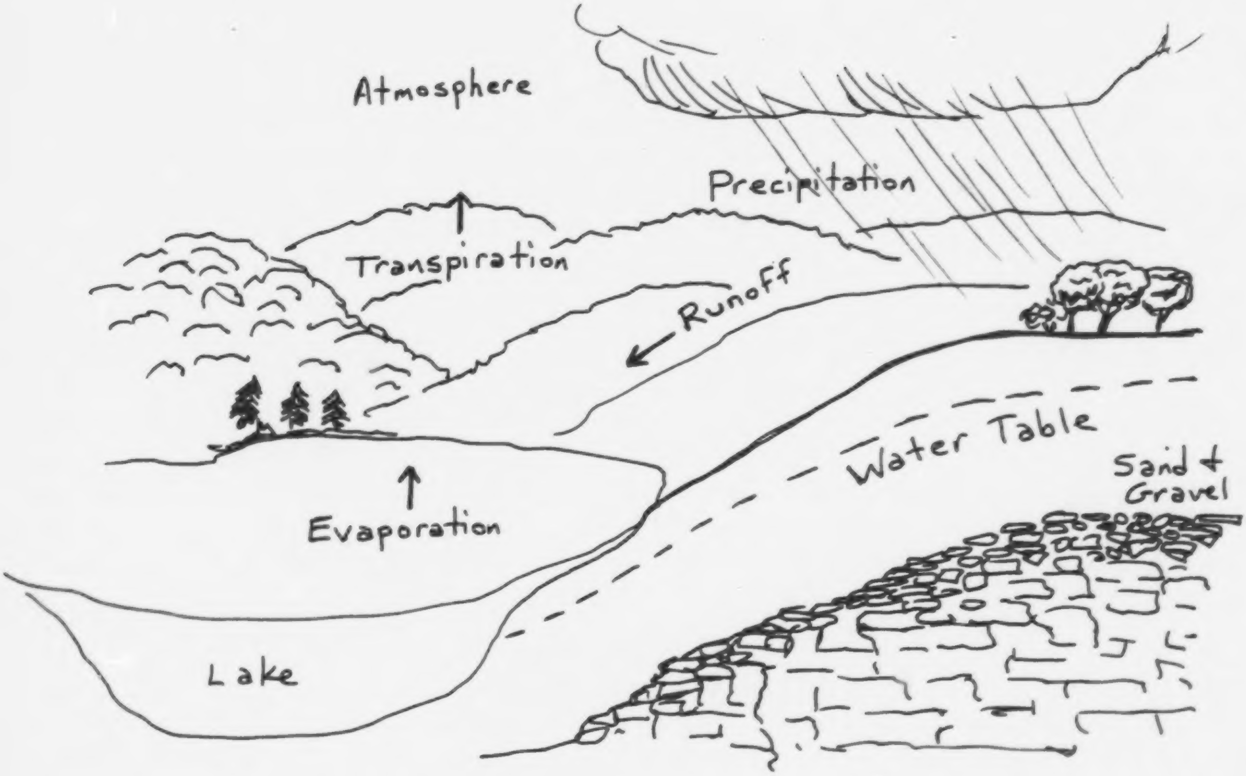

Atmosphere
Precipitation
Transpiration
Runoff
Water Table
Sand & Gravel
Evaporation
Lake

Figure 1: The Hydrologic Cycle

The Sounds of Water

Grades: elementary
Objective: to introduce the steps of the water cycle
Subjects: General and Earth Sciences, Music

Materials: a quiet area to perform the activity

Information:

"Wonder is the beginning of wisdom." - *Greek Proverb*

The water cycle - a process whereby the earth's water is moved by the energy of the sun and the force of gravity through a cycle of evaporation, condensation, precipitation and accumulation. From rainfall to water seeping into the soil to runoff and evaporation, water makes distinctive sounds that we can use to identify these steps in this natural cycle.

This quiet activity is an interactive way of beginning an exploration with your class into the the wonders of the water cycle by introducing them to the sounds of each step in the water or hydrological cycle.

Procedures:

1. Have the students begin by sitting on the floor in a large circle with you in the center.
2. After discussing the water cycle, explain to the students that they will be creating their own water cycle symphony. They will be the musicians and you will be the conductor.
3. Explain that you will be walking past each student in the circle while you are making a sound representing a step in the water cycle musical score. As you pass each student, he/she should join in on making the sound that you are making, continuing until you return with a new sound or action for them.
4. With each rotation around the circle, change the motion and sound following the progression listed below. The water cycle musical score will take you through a rain storm (starting slowly and building) to the sounds of runoff and seeping water to the interpreted sounds of evaporation. Once you have reached the end of the list, begin the pattern again to demonstrate the continuous nature of this resource's renewing cycle.

The Sounds of Water

- slowly tapping your right index finger on open left palm
- tapping the same finger at a quicker pace
- snapping your fingers at a moderate pace
- gently rubbing your hands together
- gently patting your lap with your open palms
- slapping the ground in front of your lap
- clapping your hands together
- slapping the ground in front of your lap
- gently patting your lap with your open palms

- gently rubbing your hands together
- snapping your fingers at a moderate pace
- tapping your right index finger on open left palm at a quick pace
- tapping your finger at a slower pace
- create a gurgling sound with your mouth
- flapping your tongue in and out past your lips
- popping your mouth with one open hand
- make hissing sound with your mouth
- start long exhale sounds with your breath
- quiet - hold your hands over your mouth
- begin the cycle again from the beginning

5. Ask the students to identify the sounds that they made with each step in the water cycle. Take this opportunity to further your discussion into the dynamics of this important cycle of nature.

Variations:

- Have the students create their own sounds to match the stages in the cycle.
- Encourage the students to listen to the sounds of water in their own environment. This can be done in the field or simply through a classroom window.
- For students that may have a physical challenge in making the motions presented, use pans of water with straws for tapping, splashing and blowing sounds into the liquids.

Watershed Discussion Questions:

- What parts of the water cycle are happening outside at this moment?
- How does water from a lake on the other side of the state end up in your backyard?
- How is the water cycle different in other parts of the world?

The Webs of Water

Grades: elementary
Objective: to demonstrate the inter-relatedness of the stages in the water cycle
Subjects: General, Earth and Life Sciences, Chemistry, Social Studies

Materials: A long length of string or yarn, paper and pencil

Information:

> "When one tugs at a single thing in nature, he finds it attached to the rest of the world."
> - *John Muir*

Often, it is difficult for students to comprehend a cycle that has stages that they are unable to witness first hand. Understanding the inter-relatedness of the steps of the hydrologic cycle from visible rain to invisible evaporation is possible through a combination of observation skills and group learning activities. The following activity is a helpful way for students to connect the steps of the water cycle in their minds as they connect a string to one another.

Procedures:

1. Begin by asking the students to stand in a circle.
2. Hand each student a piece of paper with a name from the list below, shuffling them as you hand them out.

The Webs of Water Characters

The Hot Sun
The Large Ocean
A Calm Lake
A Raging River
A Babbling Brook
A Fluffy Cloud
Heavy Rain
Light Snow
Thick Fog
A Small Puddle
Dry Soil
Deep Groundwater
A Large Oak Tree
A Thirsty Deer
A Sweaty Human

3. Give the group some time for each person to make up an action that represents the item on their card.
4. Using each student's motions and movements as clues, have the class guess the identity of each person. After each person's item is identified, hand the sun the end of the piece of string. Next hand a length of string to any character which has water that is effected by the sun's heat. With each hand-off, have the students explain their connection to the group. Continue making the connections between the characters, creating a web of string and ideas. For example: a series of connections may be, the sun to the ocean to a cloud to rain to the puddle... The web begins to appear as the group finds that many of the characters are related to many different characters of the cycle.

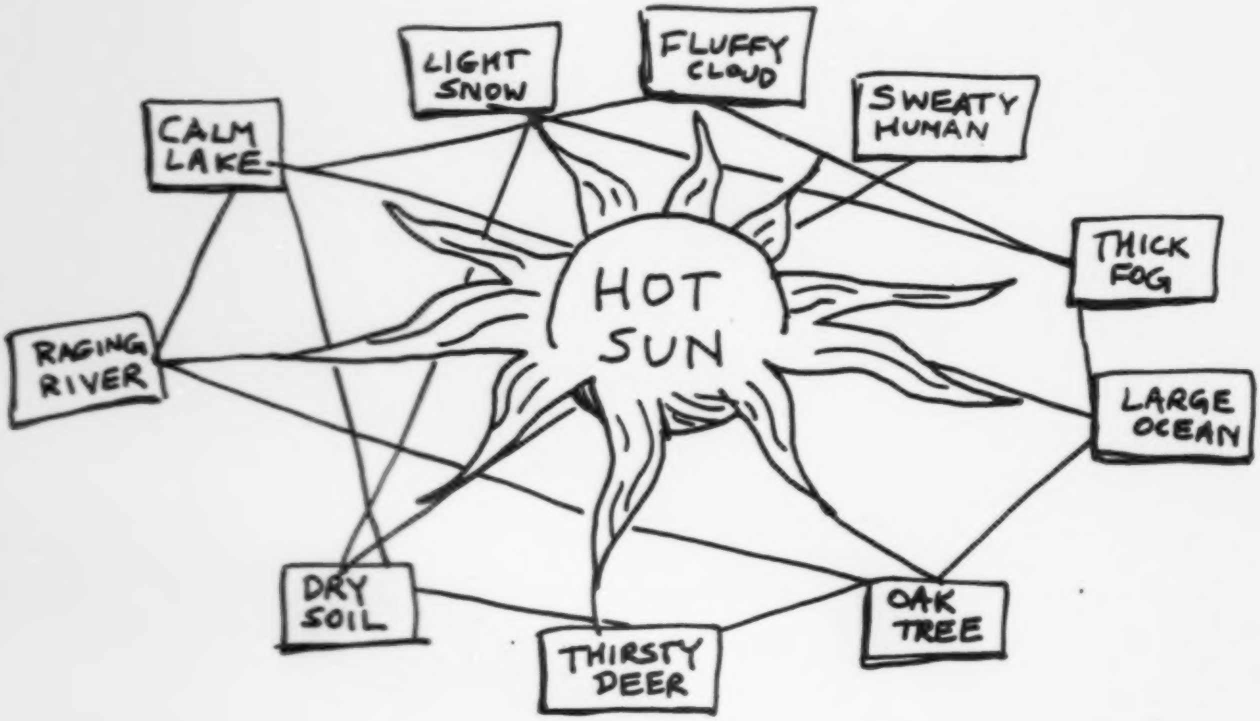
5. To aid the students in finding the relations and dependence between the items, propose the scenario that a drought entered the area so all of the forms of the precipitation disappeared. Have the rain, snow and fog students drop their lines and illustrate how everyone else is then affected.

Variations:

- Have the students find visual examples of condensation, evaporation and precipitation. An example of these terms may be a puddle disappearing in the sun or have the students breathe closely on a mirror or chalk board watching the condensation evaporate from the surface.
- Create a water cycle game of charades in which students act out stages of the cycle for the others to identify.
- Give each student an identity in a straightforward water cycle (i.e. solar radiation heats up water particles, water vapor rises, water vapor condenses on dust . . .) and have the group line themselves up in a circle illustrating the order of water cycle.

Watershed Discussion Questions:

- How do you explain the fact that there is the same amount of water today as there was 3 billion years ago?
- How do your daily actions affect the water cycle?
- Are there any events in your community that affect the water cycle?



Plants Sweat!

Grades: elementary and middle
Objective: to illustrate the process of transpiration in plants
Subjects: Earth and Life Sciences

Materials: Outdoor areas with a variety of surfaces, clear plastic wrap

Information:

The American Heritage Dictionary defines transpiration as "The act of transpiring, especially through the stomata of plant tissue or the pores of the skin". To transpire is to "give off vapor . . ." Transpiration is a method for disposing of waste products, regulating water and temperature of an organism. "Scientists say that about 4,000 gallons of water transpires from a 1-acre cornfield in one day." - *Water Week, by Channing L. Bete Co., Inc.*

Plants can sweat! This process can be hard to imagine, but it is actually easy to demonstrate to your students with the following experiment.

Procedures:

1. Begin by bringing the students outside or to a window on a sunny day. Discuss the acts involved in evaporation and transpiration.
2. Divide the students into small groups of two or three. Give each group two pieces of clear plastic wrap. Demonstrate to the students that if you keep a piece of clear wrap over a grassy area or other types of plants in the sun, the water vapor given off by the plant will condense on the wrap.
3. Challenge the students to find two different places in the area that have different transpiration rates (i.e. a grassy area is very different from a dry pavement area.). Gather the students to discuss their findings.

Variations:

- Perform a similar experiment by placing two potted plants into clear plastic bags. Put one plant in a cool dry place and the other in a sunny window. After some time, note the differences in the transpiration rates. It is also interesting to see the difference in transpiration rates on different trees. Simply place the plastic bags over sections of tree branches and watch for the moisture.
- To see the difference between the amount of water vapor from a plant's transpiration and evaporation of moisture from soil, cover a potted plant and a pot of moist soil separately in the sun and observe their differences.
- To find the location of transpiration in plants use several plants in the sun covering different areas of the plants with petroleum jelly (i.e. the stem, the top of a leaf or the bottom). Note the effects on the different parts of the plants through time.

Watershed Discussion Questions:

- How do we protect ourselves from dehydration? How do plants?
- How does the water from the leaves of trees enter the water cycle?
- If trees drink water, why don't we remove them from our watersheds?

Counting Raindrops

Grades: elementary and middle
Objective: to take a closer look at a specific step in the hydrologic cycle, students can make their own rain gauges in order to capture and measure their local rainfall.
Subjects: General and Earth Sciences, Math

Materials: One clear 1 qt. size plastic pop bottle per group, scissors, tape, markers, a ruler

Information:

"Rain like a swarm of crystal bees" - *Bob Shacochis*, Outside

What does it really mean when the meteorologist on the news tells us that we received two inches of rain last night? Does that mean two inches spread over the entire community or did it rain two inches everywhere? Or was it two inches here and maybe only one inch over there? The average precipitation of the entire state of New York is said to be 40 inches of water per year. That's about 90 billion gallons of water a day! The amount of rainfall in the Catskills which has the highest rate of annual rainfall in the state, varies not only from season to season but also according to the locations in the mountains. (To find out more about the annual rainfall of the Catskills, see *Gallons Per Minute* in this guide.)

This activity will help students become familiar with the measuring devices used to describe the magnitudes of our rain storms by leading them through the procedures for making and monitoring their own do-it-yourself rain gauges.

Procedures:

1. With students working either in groups or individually, follow the directions for assembling these simple rain gauges.
   A. Begin by cutting the top off of one clear 1 qt. size plastic bottle. Since the top is to be inverted onto the bottom half of the bottle, make sure that the diameter of the large end of the top (the funnel) is the same as the diameter of the rest of the bottle.
   B. Turn the top over and attach it with tape into the bottom of the bottle to serve as a funnel.
   C. Calibrate the bottle in inches and centimeters to measure the rainfall that the gauge catches.
   D. Secure the bottle in an area free from overhanging obstacles so that the funnel is a few inches above the ground level. * Note: It is important to secure the bottle as level as possible.
2. The gauges are now ready to collect and measure any amount of precipitation in that area. Have the students periodically check and record any rain, snow, dew, etc. that accumulates in their gauges. A ruler may also serve as a dip stick to measure the daily precipitation.

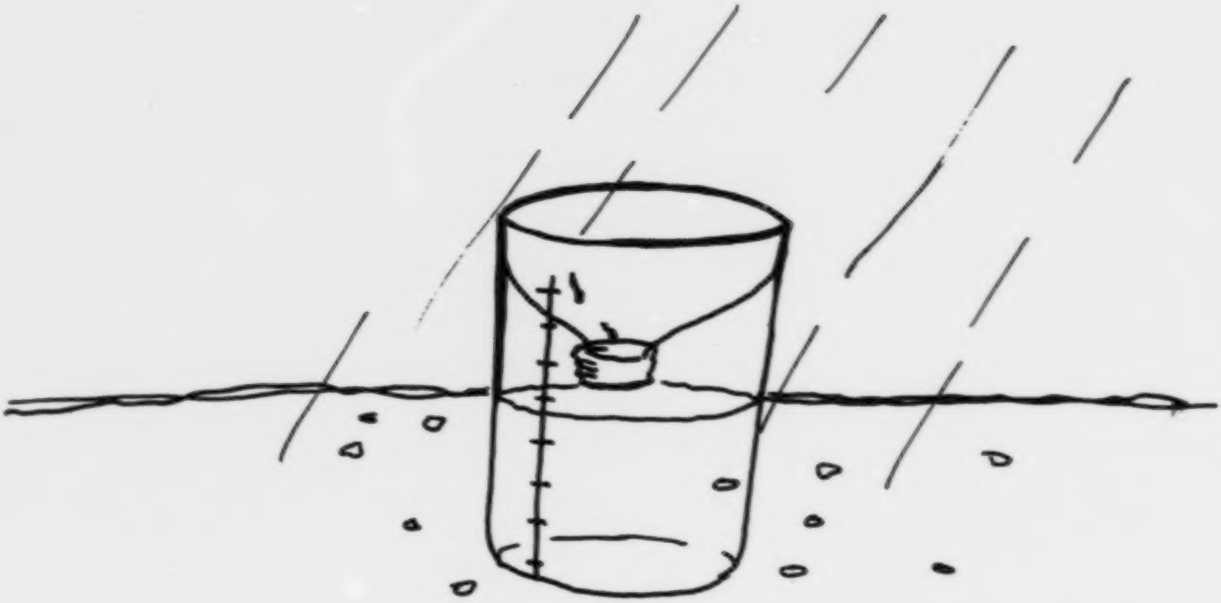
Variations:

- Have the students place their gauges in different locations around the school area and compare and contrast their findings.
- Perform some water quality experiments on the water collected. See *The Pollution Sources of the Watersheds* section of this guide.
- Do this activity with snowfall and measure the difference in the amount of snow and the amount of water produced from the melted snow. (generally 1 inch of rain = 9 - 10 inches of snow)
- Measure the area of school grounds and use this figure with the amount of rainfall to calculate the volume of rain that fell on the grounds during a particular day.

Watershed Discussion Questions:

- Where in your community does the rain go after it falls to the ground?
- Which area in New York State gets the most annual rainfall? In the U.S.? In the world?
- What causes one area of the state to get more rain than another?

Source: Adapted from *Rain Gauge* in The Official Capt. Hydro Water Conservation Workbook



The Clean Water Girl & The Solar Water Cleaner

Grades: all grade levels
Objective: to increase students' global awareness and illustrate how to use the water cycle in cleaning a sample of water
Subjects: Earth and Life Sciences, Social Studies, Health, Chemistry

Materials: A small amount of soil, a half gallon of water, a large bowl, a glass, clear plastic wrap, a dozen stones, a sunny day, *The Clean Water Girl Story*

Information:

"By the year 2025, one out of every three people in the world will live in a country with a water supply problem" - Hydata, January '94

The following activity should not only help students become aware of the problems of impure water in developing areas but also help them use their knowledge of the water cycle to demonstrate a creative way of solving the problem in small communities. For younger groups, read The Clean Water Girl Story to introduce them to the concerns of water quality and quantity, then go on to build the water cleaner.

The Clean Water Girl Story

In the United States, most water is tested then treated with chemicals before it comes to our homes in order to make sure that it is clean and safe to drink. But in many parts of the world, water is not cleaned. It may look clean and safe to drink but it contains germs called pathogens that can make people sick and even kill them.

The most common disease caused by germs in dirty water is diarrhea. Every year, millions of people die from diarrhea. Most of them are children.

Here is what one girl did to help her family and her village make sure that their water was clean and safe to drink.

Awo (Ah-woe) was an eight year old girl who lived in Ghana. Ghana is a country in Africa.

Awo was worried. Her mother was going to have a baby. Why wasn't Awo happy about this? She was! She very much wanted a baby sister or brother. But she was worried because just a year ago, her baby brother died from diarrhea. He got the diarrhea from germs in the water that he drank. Awo was afraid that the same thing would happen to this new baby.

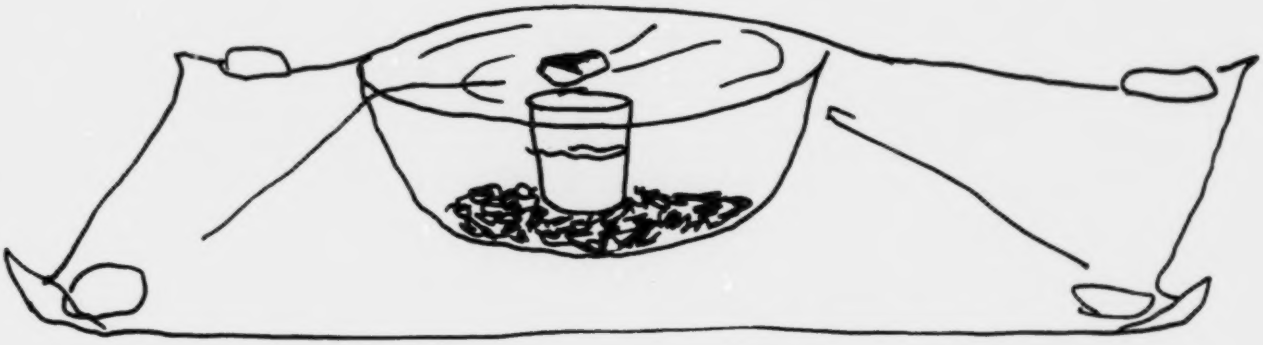
One day a health worker came to Awo's school. She told Awo's class about a way to make water clean. It was called a solar water cleaner. The health worker said that the solar water cleaner would make the water safe to drink. She showed the children how to make one.

Awo rushed home after school and made a solar water cleaner. She showed it to her mother. Her mother smiled. She thanked Awo for helping to keep the whole family healthy.

The solar water cleaner worked. When the new baby was born, it stayed healthy. So did Awo. When the other people in the village saw how Awo's solar water cleaner got rid of the germs in the water, they made cleaners also. Soon everyone in the village was drinking clean water. There were very few cases of diarrhea. The villagers called Awo "The Clean Water Girl"!

Procedures For Making a Solar Water Cleaner:

1. Mix a small amount of dirt into about a half gallon of water.
2. Pour the dirty water into a bowl.
3. Stand an empty glass right side up in the center of the bowl.
4. Place the bowl in a sunny location and cover it with plastic wrap, holding down the edges of the plastic with stones.
5. Place a stone on the plastic cover over the center of the glass.
6. Leave the water cleaner in the sun all day.
7. Remove the plastic. Look in the glass. What do you see? (It should contain clean water.) Look in the bowl. What do you see? (It should contain the dirt.)
8. Discuss with the group how using the water cycle helped them clean the water.



Variation:

- Compare and contrast this method of cleaning water with putting the water through a cloth filter, sedimentation, etc. (See *Cleaning-up Our Wastewater*)

Further Discussion Questions:

- What are some different ways in which people can use clean water?
- Other than germs, what other things could be in our drinking water?
- How does your community clean its water?

Sources: Adapted from *The Clean Water Girl and Solar Water Cleaner* in Taking the World to Camp and UNICEF's, Within Our Reach - Helping Students Develop an International Perspective, 1989

The Hydrology of the Watersheds

Assessment Tools

It is a common desire of all educators to know if the students are retaining the information and skills being taught. Because of the nature of experience-based activities, it is often difficult to quantitatively score the students' understanding of the subject. The goal of these sections in each of our chapters is to supply some formal and informal means for assessment of the students' learning successes.

Poetry in the Motion of Water

"A poem begins in delight and ends in wisdom." - *Robert Frost*

- Encourage your students to write poems about water and the hydrologic cycle. Some examples of poetry forms are:

The Haiku

a Japanese form of poetry written to express a reaction to something in nature

Formula	Example
1st line uses 5 syllables	Rain falls to the ground
2nd lines uses 7 syllables	Cool water plays amongst the rocks
3rd line uses 5 syllables	gently flowing down

The Cinquain

Spanish and French term for the number five

Formula	Example
1st line is the title in 2 syllables	Water
2nd line describes the title in 4 syllables	cool and flowing
3rd line describes the action in 6 syllables	wears rocks into pebbles
4th line expresses a feeling in 8 syllables	often touching and surrounding
5th line restates the title in 2 syllables	current

The Windspark

Formula	Example
1st line "I dreamed"	I dreamed
2nd line "I was" someone or something	I was water vapor
3rd line describes where	floating in a cloud
4th line describes the action	collecting into a rain drop
5th line describes how	slowly

The Hydrology of the Watersheds

Class Follow-up Projects

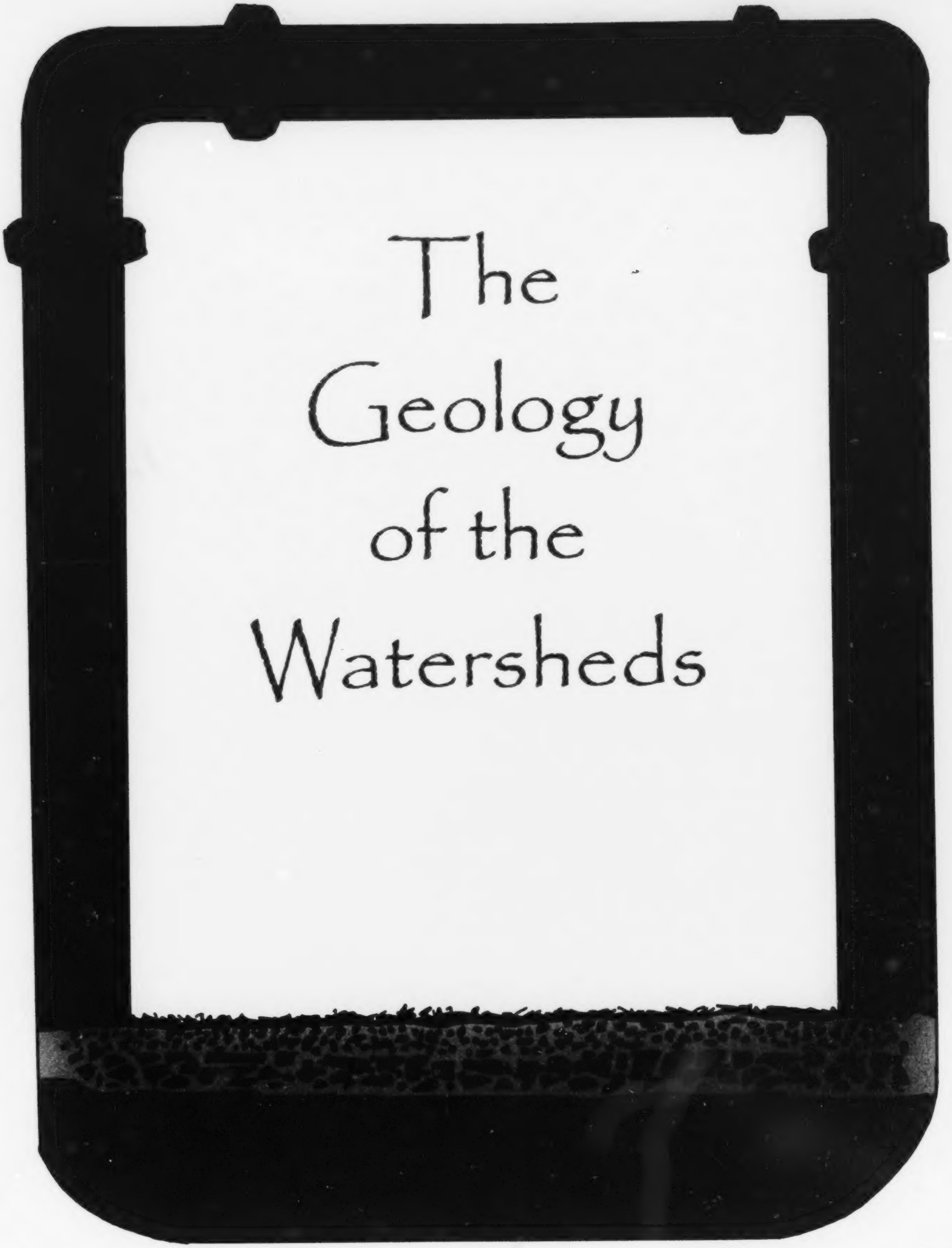
"Anyone who says you can't see a thought simply doesn't know art."
- *Wynetka Ann Reynolds*

If, after this section on The Hydrology of the Watersheds, the class is eager to build on these lessons, incorporate a few successful follow-up projects on the subject.

Making Water Music:
- Ask the students to compose a musical piece that illustrates a contemplation of water (i.e. a babbling brook, an ocean storm).

Creating a Water Library:
- Have the students make, write and illustrate big books on the subject of water.

Hydro Art:
- Organize a poster contest on the subject of water for your school or township. A current successful poster program is run by the New York City Department of Environmental Protection in cooperation with many New York City Schools. Call their offices for more information.



The Geology of the Watersheds

The Geology of the Watersheds

This section of our guide includes the following:

- information inserts - - on the subjects of soil erosion and the geology of the Catskills
- a variety of activities exploring topics in the classification of soils, permeability, erosion, groundwater, topography, beginning map making and how these dynamics affect the ways of the watersheds

Water and Soils

Defining Soils
to investigate the components and nomenclature of soils

Mystery Soils
to use students' senses in comparing and contrasting soil types

Soil Labyrinths - Stopping the Drops
to illustrate the permeability of water through different materials

Water's Journey Through the Mountains
The Geology and Orography of the Catskills

The Power of a Drop
to illustrate the effect of precipitation on various surfaces

See What I See?
Copy Cat
My View Of Things
Line Up!
to give students the opportunity to use observation and beginning map making skills

The Lay of the Land
to illustrate how ground composition and topography affect the rate of water seepage, runoff and reservoir formation

Pump It Up
to illustrate the movement of groundwater through soils

The Trouble With Turbidity
to measure the amount of turbidity caused by dissolved or suspended materials

Assessment Tools

Class Follow-up Projects

Water and Soils

> "What is of all things most yielding, can overcome that which is most hard,
> being substanceless, it can enter in even where there is no crevice.
> That is how I know the value of action which is actionless." - *Lao Tzu*, 5th century B.C.

Under ordinary conditions, the water that falls onto land as precipitation is either used by plants, seeps into the soil replenishing the groundwater or evaporates back into the atmosphere. The impact of water on land often changes the landscape. Precipitation, water currents and wind often wear away sediment (small particles of soil and other matter) from the land. This action is known as **erosion**, or the detachment and transportation of soil particles.

The impact of a raindrop on bare soil is like a small explosion on the surface, sending small particles in every direction. Erosion can cause several effects considering the amounts of rainfall or the variety of movements and paths water follows over land surfaces. **Sheet erosion** occurs when agitated water keeps particles in suspension as a sheet of water flows downhill. This type of erosion removes a thin, uniform layer of soil. A more noticeable effect is present with **rill erosion**. With this type of wearing, concentrated runoff follows surface depressions or around obstructions, thus intensifying the water's effects creating rills, or small channels. **Gully erosion** happens in areas where either the effect of the water movement is powerful on the soil or the soil's resistance to erosion is low causing a scouring action, leaving large, deep crevices.

As erosion is the lifting of particles; sedimentation is the settling of the sediment. Erosion and sedimentation are natural processes, yet today they often occur at unnaturally high rates. Due to human activities such as poor farming practices, removal of natural vegetation, construction sites and development of land, sediment loading has become by volume our single largest water pollutant. Excessive amounts of sediments become harmful to water because of its ability to:

- carry chemicals such as toxins that can accumulate in a food chain,
- aid in the transport of infectious parasites such as *Giardia lamblia*,
- cloud waters thus decreasing water column light availability for plant and animal life, or
- causes nutrient loading and artificially high rates of plant growth which in turn destabilizes the ecology of the waterways, and
- fill in waterways thus burying bottom surface dwelling plants and animals.

In order to begin to understand the dynamics between water and New York State soils, it is important to explore topics such as characteristics of our soils, their permeability, topography, ground and surface water relationships as well as runoff and erosion. The following activities will guide your students through investigations into these subjects of New York's water and soils.

Defining Soils

Grades: elementary and middle
Objective: to investigate the components and nomenclature of soils
Subjects: Earth and Life Sciences

Materials: Outside areas with a variety of soil surfaces, garden trowels or large spoons, a number of jars with lids, water, 3-6 inch diameter plastic pipes or metal core samplers, copies of the Soils Type Dichotomous Key

Information:

> "**Soil** (soil) n. 1. The top layer of the earth's surface, suitable for the growth of plant life, 2. A particular kind of earth or ground: *sandy soil*. 3. Country; land: *native soil*. 4. The agricultural life; *a man of the soil*. 5. A place or condition favorable to growth. [ME<AN, a piece of ground<Lat. *solium, seat*.]" - *The American Heritage Dictionary, Second College Edition*

Defining soils is not as simple as the dictionary presents. Soils serve a multitude of uses from providing habitat for insects and other burrowing animals, to foundations for our buildings, to providing storage for groundwater. Every location exhibits a variety of distinct and ever-changing soil characteristics. This variety is also three-dimensional. Soils are as different in chemistry and structure from the top to bottom as they are from place to place. The variety is in large measure what defines soil's significant role in sustaining life on this planet.

Soils are made up of many different components. Of these, the bulk of most soils is inorganic, or non-living matter. The organic part, living or once living matter, of soil uses the inorganic components as a support structure or "matrix" as well as a source of mineral nutrients for supporting plants growth. Soils are obviously more than just dirt, but to many students, soil is just something that they walk on. The easiest way for students to get to know what constitutes soil in New York State is to go ahead and dig right in, anywhere.

Procedures:

1. In exploring the ingredients in a soil recipe, have the students start by collecting small soil samples (one or two cups) from a variety of areas such as forest, field, river bank or a parking lot.

2. Instruct the students to place each of their samples into jars 3/4 filled with water. Cap the jars and shake them vigorously. Set the jars on a table to let them settle.

3. After a few minutes, check back on the jars to find the layers of materials that have settled.

4. If definite layers appear in the jars, measure the layers and calculate the percent of each type of material using the following formula:

$$\frac{\text{depth of each layer}}{\text{total depth of soil}} \times 100 = \_\_\_\ \%$$

5. To investigate the composition of the materials in soils, give the students a small length of 3 - 6 inch diameter plastic pipe.
6. Using metal core samplers and/or plastic pipes with one end filed thin or sharp, instruct the students to push a pipe a few inches into one of their patches of ground. Have the students slowly remove their pipe from the ground with the soil column remaining inside of the tube. Depending on the location the students choose to make their samples, they may find it difficult or even impossible to push the pipe very far into the ground. This is a perfect opportunity for a discussion on compaction and soil permeability.
7. Next, carefully remove the soils from the pipes with sticks or pressure while keeping the soil columns intact (a rubber spatula works well in keeping the columns in tact when trying to transport the soils to a container.). In this profile, the student should be able to note the layers (soil horizons) and components of the soil from each area. Use this opportunity to further compare and contrast the different locations. (Note: If pipes are not available to you, garden trowels or large spoons with careful excavation will work just as well.)
8. Next, use the following Soils Type Key in order to discover the names for the soils the class has been investigating. (The term "loam" denotes a mixture of sand, clay, silt and organic matter)
9. After researching the ingredients, compositions and classification of a variety of soils, discuss the natural and/or human conditions that affected the diversity that they found.

Variations:

- Create for the class a terrarium tank filled with layers of soil materials demonstrating the composition and horizons of the soil in your area. Explore the possibility of obtaining some plants, insects and amphibians to live in the new habitat.
- Demonstrate how rocks break down to form soil by having the students take two pieces of rock and rub them together to make small particles. Mix in water and/or inorganic and organic materials in order to create a diversity of soils.
- Create your own nutrient-rich soil from table scraps using a variety of composting activities, i.e. composting in jars in the classroom, backyard models for the school yard or a small-scale vermiculture (composting with worms).
- Illustrate the ingredients needed in making soil with younger students by creating a soil recipe. Using a large bowl and spoon, have the students add the items that make-up the soils in their area. (*Note: Don't forget the secret ingredient, time!)

Watershed Discussion Questions:

- What is the history of the geology of your area?
- What types of soils make up the land in your community?
- What activities in your community effect the condition of your soils?

Source: Adapted from *What is Soil?* in Land and Soil

Soils Types

A Dichotomous Key

1. Is the soil gritty (contains tiny rough granules)?
   If Yes .... go to #2
   If No .... go to #3

2. Will the soil stay together in a firm ball?
   If Yes .... This soil is a **Sandy Loam**
   If No .... This soil is **Sand**

3. Is the soil sticky and rough?
   If Yes .... go to #4
   If No .... go to #5

4. Is the soil hard to squeeze?
   If Yes .... This soil is **Clay**
   If No .... This soil is a **Clay Loam**

5. Is the soil smooth (soft and silky)?
   If Yes .... This soil is a **Loam**
   If No .... This soil is a **Silty Loam**

Mystery Soils

Grades: elementary and middle
Objective: to use students' senses in comparing and contrasting different soils
Subjects: Earth and Life Sciences, Language Arts

Materials: An outside area with a variety of soil surfaces, blindfolds

Information:

"There seems always a depth, somewhere, unexplored, a thicket that has not been seen through, a corner full of ferns, a quaint old hollow tree, which may give us something."
- Richard Jefferies

To completely observe the many visual, tactile and odoriferous characteristics of soils, it is important to utilize all of our senses. Often by hindering our sense of sight we become more in-tune with observing things through touch, smell, taste and hearing.

Procedures:

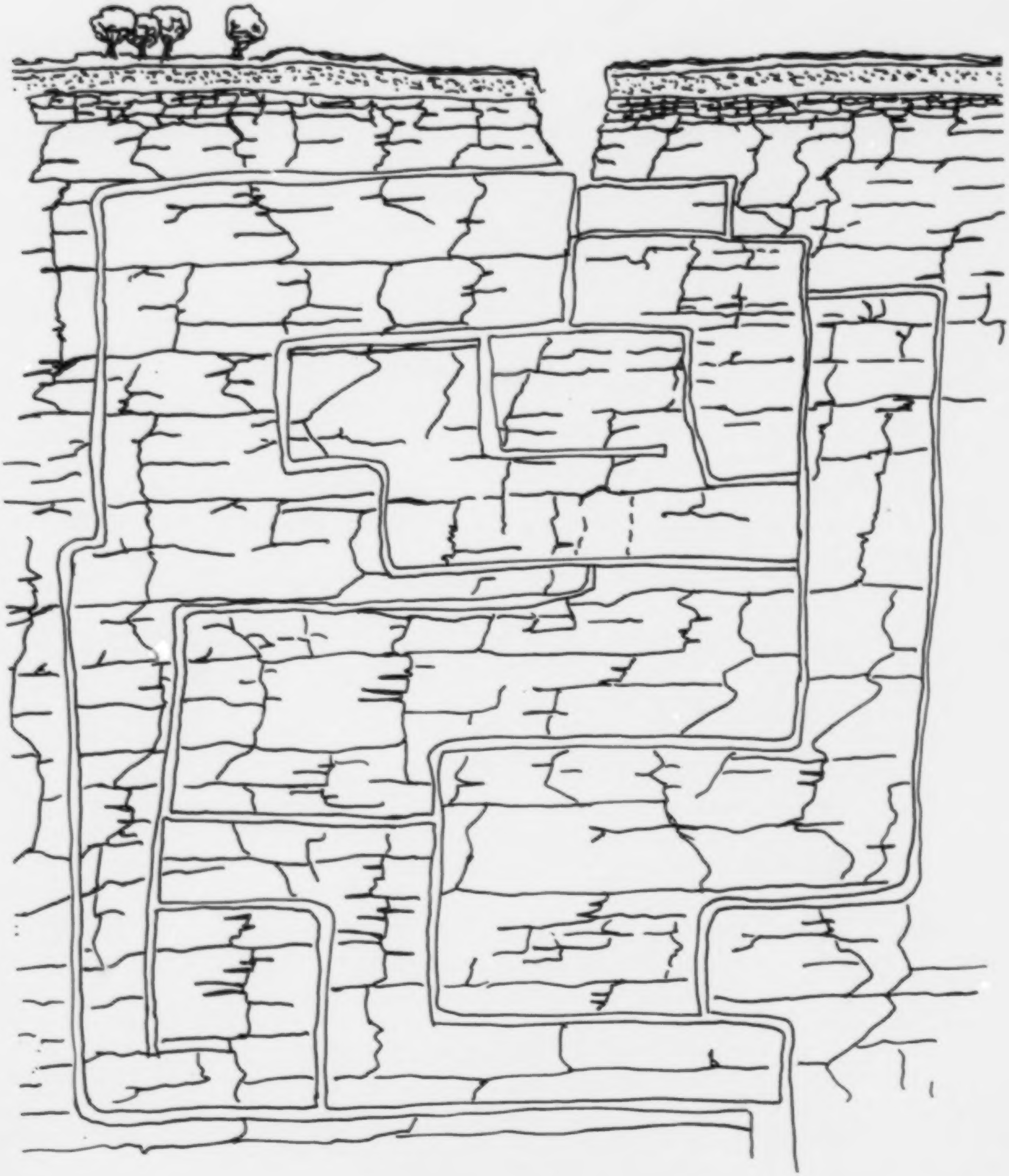
1. Begin by asking the students to find a partner. Hand each pair one blindfold. Explain to the students that in order to get all of the information possible about particular soil surfaces, they need to observe with their hands, ears and nose in addition to their eyes. This activity is best done outside but if you are unable to take the students outdoors, this it can be done with a variety of different soils and surface types displayed in a number of pots or piles on a counter. Instruct the students that when they begin this exercise they should place the blindfold on one of the partners. It is the sighted partner's job to watch to make sure that their partner is safe at all times during this activity. (*Note: You may want to supplement this safety monitoring yourself.) The sighted student should take their blindfolded pal to a location nearby and place their partner's hand on a patch of ground.
2. They should then give their partner time to explore the area and its close surroundings with their hands, nose and ears in order to find out as much information as they can about this spot without using their eyes. (*Note: Be sure to instruct the students never to taste anything during this activity.)
3. After their partner has gathered all of the information possible about their location, the sighted student should then carefully lead their partner away from the spot. When they are a fair distance away from their exploration spot, they should then remove the blindfold and challenge their partner to find the location they took them to. If the students choose, they may hint to their partner if they are getting close or not.
4. After they have located their spot, have the students switch roles blindfolding and leading the other partner to a different location. When everyone has had a turn, gather the group together and discuss their observations. How were you able to find your location? What clues did you use in order to differentiate your soil from others?

Watershed Discussion Questions:

- The Catskills are predominately made up of sandstone. What does this rock feel like?
- How is the sedimentary material sandstone different from metamorphic material marble or the igneous material of granite?

The Ways of Water Through Soil

Follow the maze to find the water's path through the soil.



Soil Labyrinths
- Stopping the Drops

Grades: elementary and middle
Objective: to illustrate the permeability of water through different soil materials
Subjects: Earth Science, Chemistry

Materials: A large open area in or outdoors

Information:

A labyrinth or "an intricate structure of interconnecting passages through which it is difficult to find one's way; maze" (*American Heritage Dictionary*) is a perfect way to describe the structure of the soils that water penetrates while seeping into ground surfaces.

The ability of water to move through soil or rock depends on the material's porosity and permeability. Water moves through different materials at different rates, faster around the larger pieces in gravel, slower around the smaller grains in sand and even slower throughout the tight composition of clay.

Aquifers are water-saturated layers of sand, gravel, or bed rock through which groundwater flows. When tapped by wells or other mechanical devices, these underground reservoirs can often yield significant amounts of water.

The following activity demonstrates how the different sizes of rock materials affect the rate of water's underground movements.

Procedures:

1. This activity is a three-part demonstration using the students as characters in the physical portrayal of water flowing through different soils.

2. Select two or three students to play the roles of water molecules. The remaining students will be rock materials.

3. First the students will act out water passing through gravel. To do this, arrange the soil students in a large group in the center of your area. Instruct them to stand with their arms straight out to the side with a distance of about a foot between their hands and the other students around them.

4. The students representing the water molecules are to start on one side of their gravel classmates and move through them, exiting on the other side. The water molecules should be able to move easily through the gravel.

5. Next the students will act out water passing through sand. The students representing sand should all stand this time with their arms extended, bending them with their hands on their hips. Arrange the students spacing them just less than a foot apart this time.

6. Once again, have the water molecules slowly make their way through their sand classmates. The water molecules will experience some difficulty, but should still reach the other side of the group.

7. Finally, the students will act out water passing through clay. The students representing clay should all stand placing their arms straight down to their sides and their bodies close, less than six inches apart.

8. Without being rough, the water molecules should make their way through the clay slowly. The water molecules may not be able to move through the clay at all.

9. Discuss with the students their observations in this activity. Which one of the materials was easiest to pass through?

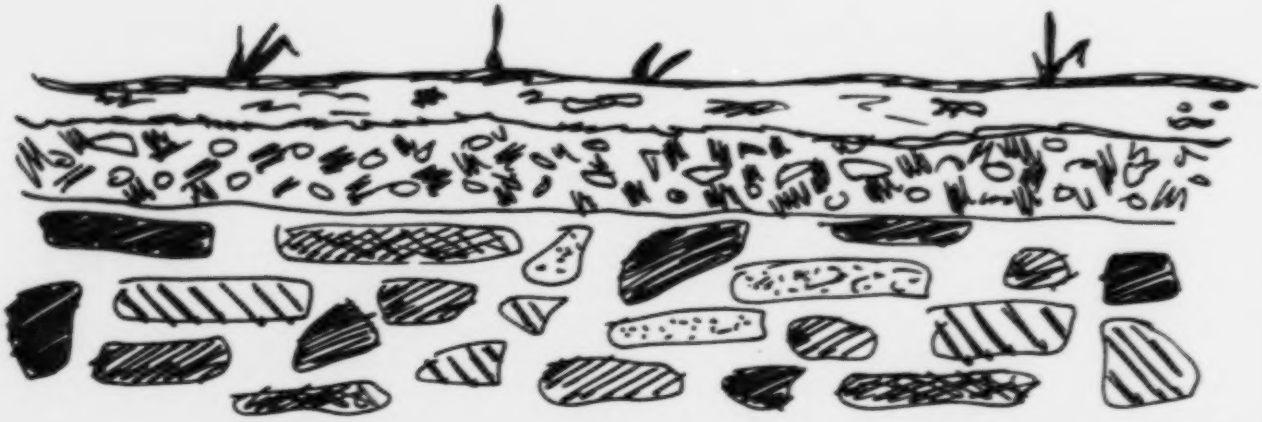
Variation:

- An interesting permeability experiment to do with middle school or high school students is to test the water drainage of various soil materials. Take an equal amount of gravel, sand and clay and place them each in funnels lined with a small piece of cheesecloth to prevent materials from going through the spouts. Put each funnel in separate clear containers so that the spout of the funnel is at least ten inches from the bottom of the container. Next create a permeability race by pouring equal amounts of water into each of the funnels timing how long it takes the water to flow through the materials. Record the data and interpret the findings with the group.

Watershed Discussion Questions:

- In which rock materials would you expect to provide the best aquifer (the greatest storage capacity) for groundwater? Why?
- If there were three rock areas, gravel, sand and clay, all containing the same quantity of water, in which would you drill a well? Why?
- If you were making a pond or reservoir, what material would you use to line the bottom? Why?

Source: Adapted from the United States Geological Survey fourth poster, *Groundwater: The Hidden Resource, Grade School Edition*



Water's Journey Through the Mountains

The Geology and Orography of the Catskills

> "There is ever a lurking suspicion that the beginning of things is in some way associated with water, and one may notice that in his private walks he is led by a curious attraction to fetch all the springs and ponds in his route, as if by them was the place for wonders and miracles to happen." - *John Burroughs*

As raindrops fall on the surfaces of the Catskill Mountains, they begin a journey through an area that has been shaped by the action of water for hundreds of thousands of years. To truly understand the ecology and human development of the Catskill Mountain region, it is important to first study the area's dynamic geological history as well as its diverse climates and water drainage systems.

Catskill Geology

The Catskill Mountains are essentially a dissected plateau. During the Devonian Period (405 to 360 million years ago), a large set of mountains, the Acadians, uplifted to the east of what is now the Catskill area. The drainage from these mountains ran from the eastern mountain slopes to the Atlantic, and from the western slopes to a shallow inland sea that covered most of what is now New York State. As the Acadians eroded through time, a thick delta of deposits formed from the settling of the sediments carried in rivers and streams. Subsequent mountain building caused this delta to rise up and become a large plateau in the area of the present day Catskills. Since that time, the plateau has been slowly carved and dissected through the constant action and wearing of water, ice, and wind over its surfaces, eventually creating the majestic peaks and valleys we know today. The peaks of these mountains, most approximately 3,500 feet (1,067 meters) in elevation, are said to indicate the original surface height of the ancient plateau. In addition, the Catskill region itself stands 2000 feet (610 meters) higher than the land extending to its south and west.

The topography of the Catskills was also modified by the action of continental and alpine glaciers which reached their maximums in the area about 22,000 years ago. The glacial margin withdrew from the region about 14,000 years ago, blanketing the surfaces with deposits from surrounding bedrock materials referred to collectively as "till".

The bedrock of the Catskill Mountains is approximately 60% sandstone and conglomerate and 40% shale and siltstone. Quartz is the dominant bedrock mineral and muscovite and amphibole are common accessory minerals (Ethridge, 1977). The till tends to be thicker in streambed valleys and thinner on the upper steep slopes of the mountains. The soils of the Catskills vary in thickness but tend to be excessively to moderately well-drained, predominately very steep and medium textured in the uplands. The pH of the soils in this region is generally acidic, though this varies depending on the location in the mountain range. United States Geological Surveys performed for the New York City Department of Environmental Protection found a gradient of pH measurements running from higher values in the Northwest sections of the Catskills (upstream from the Cannonsville reservoir) continuing to lower measurements toward the Southeast sections of the range (upstream from the Neversink and Rondout reservoirs). Geologic studies and hypothesis are still on going correlating the amount of Calcium Carbonate present in the glacial till and bedrock with the corresponding gradient in acidity of the stream waters. These ongoing studies hope to substantiate that the acidity of the region is indeed a reflection of its base-poor local bedrock.

Journey Through the Watershed

The climate of the Catskills is classified as humid continental with cold winters and moderately warm summers. Due to the variation in elevations within the watershed, there are distinct spatial variations in temperature and precipitation. The mean annual temperature at Slide Mountain, the tallest mountain in the Catskills, is measured to be 3.3°C at the summit. Whereas in the town of Liberty, NY, located just outside of that watershed basin with a much lower elevation, the mean annual temperature is 7.2°C (NOAA, 1990).

The mean annual precipitation in parts of the Catskills is recorded to be among the highest in the Northeast. As with the temperatures of the region, the amounts of precipitation for the Catskills varies greatly at different locations. The mean precipitation figures for Slide Mountain can be as high as 175 cm/year (Iorio, 1972) with the mean precipitation for the weather station at Claryville, a town approximately 14 miles down the valley, recorded to be 140 cm/yr (1950-85 mean; NOAA, 1985). A combination of the orography (the physical geography of a mountain range) and the incoming Atlantic storm weather patterns approaching from the southwest account for the high amounts of precipitation and uneven distribution of rainfall.

The large amounts of annual precipitation for the Catskills results in an annual runoff which is also one of the highest rates in the Northeast. The Catskills are drained by several major river systems. The East and West Branches of the Delaware River drain the western half of the environment into the Delaware Bay. Other important tributaries to the Delaware are the East and West Branches of the Neversink River, the Beaverkill River and their associated streams. To the east, the major drainage enters the Hudson River through the Esopus watershed and a series of streams which enter the Hudson directly. To the north, the Schoharie Creek is the major drainage which drains a large portion of the northwestern corner of the Catskills. Earlier in this century, the New York City Department of Environmental Protection created a series of reservoirs and aqueducts in order to capture these massive flows of water from the Catskills and divert them south to provide the City and surrounding communities with an abundant source of drinking water (See *Harnessing the Headwaters*).

The Power of a Drop

Grades: elementary
Objective: to illustrate the effect of precipitation on various surfaces
Subjects: Earth Science, Math, Social Studies

Materials: Small white stakes (1-2 ft in length), rulers, water-proof marking pens

Information:

"Raindrops applauding themselves on the pavement" - *Crystal Noer*

The impact power of a drop of precipitation sends surface materials scattering. This initial loosening and movement of soil particles can be the beginning of erosional changes in many surfaces. The activity is a simple observation experiment using calibrated stakes that illustrate the basic action of erosion and how bare ground is more vulnerable to weathering from water than ground covered with vegetation.

Procedures:

1. Begin by giving each student two stakes. If stakes are not available, tongue depressors taped together will work well also. Instruct the students to calibrate their stakes in inches and centimeters using a ruler and water-proof pen.
2. Choose a time before a forecasted rain shower to bring the students outside. Instruct the students to place the stakes in various locations around the school grounds. After it rains, they will be able to record the differences in the amount of soil splattered from each surface onto the stakes. Instruct the students to set-up each of their stakes in two very different locations (i.e. in open soil and in the grass) and to take care to push them into the soil so that the one inch mark on their stake is exactly one inch from the surface.
3. Wait for it to rain. (Note: This activity works well if you set everything up at the end of a class day and after an evening rain, your class should check them in the morning. Have the students check and record how high the raindrops splashed spots of mud. With the students that used similar ground surfaces, encourage them to average the height of the highest and lowest splatterings for comparisons with other areas.
4. Discuss with your students the results of the activity. Did the mud splash higher in the areas with bare ground or the areas with vegetation? Why is it important to know the effects of rain's impact on an area? (*Note: If possible, try this activity in different forested areas comparing deciduous with coniferous cover and also slope intensity.

Variations:

- For groups unable to go outside, set up boxes of different soil materials and compare the different effects on them caused by pouring water from a set height simulating rain.

Watershed Discussion Questions:

- Which places in your school yard is rain causing damage?
- How can these areas be altered in order to slow or prevent this damage?
- How does erosion affect water quality?

Source: Adapted from *Splatters* in Land and Soil

See What I See?

Objectives: to help students practice skills in observation and beginning map making
Subjects: Earth and Life Sciences, Math, Art, Social Studies

Information:

"The most poetic and truest account of objects is generally given those who first observe them, or the discoverers of them." - *Henry David Thoreau*

The following three activities, *Copy Cat*, *My View of Things* and *Line Up!*, are a series of observation and beginning map making lessons that will help students become acquainted with the inspections skills and mathematics involved in the craft of cartography.

Copy Cat

Grades: all grade levels
Materials: A bandana, a natural area

This is a simple observation skills activity that you can adapt to the grade level and abilities of any group of students. This activity can be done inside a classroom but when connected with a lesson on the environment, it is best done outside.

Procedures:

1. While you are walking with the group in a natural area, inconspicuously pick up different objects from the environment (i.e. a rock, leaf, piece of wood). Stop the group in an area that they can be free to explore on their own. Ask the students to close their eyes and quietly count the different sounds that they hear in this spot. While the students are distracted, arrange the objects you have collected on the ground and cover the design with the bandana.

2. After discussing with the students all of the different sounds that they heard and our different senses we can use to explore an area (sight, hearing, taste and touch), explain to them that you will be asking them to use their sense of sight and observation skills for this next activity. Gather the students around the bandana. Instruct them that they will be given a brief peek at the arrangement under the bandana (~10 to 20 seconds) and it will be their task to look around the immediate area to find objects similar to the objects that you have under the cover. * Note: Due to the nature of the students' explorations and manipulation of their surroundings during this activity, it is important not to use parts of living plants or animals that may walk out from under your bandana.

3. After they have the objects they need, have them place their objects in the same pattern that they remember your objects being arranged. Take time to compare the students' efforts and discuss the causes in the variety of patterns created (different people's observations, different objects, individual's perceptions, etc.).

Watershed Discussion Questions:

- How do you explain two people looking at the same thing and seeing different images?
- How does this lesson help us understand why NYC and Catskill Community residents see different things when they each look at the City's reservoirs?

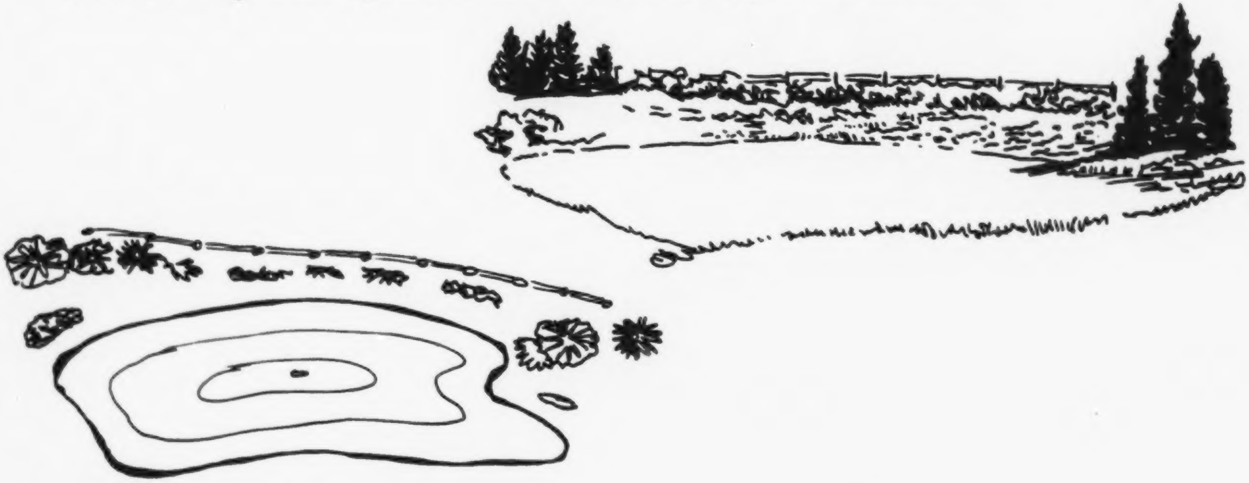
My View of Things

Grades: all grade levels
Materials: Paper and pencil, an area with a variety of settings (preferably outside)

These are simple activities that start students on the skills involved in map making. They can be adapted to the grade level and abilities of any group of students. These activities can be done inside a classroom but when connected with a lesson on the environment, they are best done outside.

Procedures:

1. Instruct the students to visually pick out an object in the area. With paper and pencil have them draw the object. Next, have them draw another picture of the object in relation to its surroundings. Finally, have them draw a picture of the object from a bird's eye view or how the object is viewed from above (also in relation to its surroundings).
2. Have the students pair up with someone in the class and trade pictures. Challenge the partners to find the location and object in their classmate's drawings.
3. Gather the group together and discuss their observations. How were you able to find your partner's object? What clues in the drawings did you use to find the spot? What additions to the drawings and maps would be useful in helping you find the location?



Variations:

Two additional activities that help build the map-making skills in perception of proportion and location are:

- Have the students draw a picture of an item with a very close view. With this picture, only a portion of the object should be present.
- Have the students draw a series of bird's eye view pictures of an area backing-up farther and farther into space. An example would be to first view the yard, then the school grounds, then the town, the state, the country and so on.

Watershed Discussion Questions:

- Why does it help sometimes to look at things in two different ways?
- If you are looking at one of the NYC reservoirs, which view, straight-on or aerial, would give you a better idea of its true size?

Line Up!

Grades: middle and upper

Materials: Paper, pencils, a semi-open area (preferably with an incline or steps), string or yarn, stakes, rulers

The following is an activity that helps students visualize how maps are made to scale and introduces them to the commonly used cartographic criteria for marking physical features on maps.

Making a map of an area is actually much more complicated than it looks. Care should be taken to make sure that a map represents the area surveyed clearly and accurately. By setting up a grid system for the students to replicate on a map, they will be able to make a topographic map of just about any area available. If you choose to make colored maps, the following are the colors that the United States Geological Survey uses for their maps:

Contour Lines	Brown
Forested Areas	Green
Non-Forested Areas	White
Physical Features (i.e. buildings)	Black
Water	Blue
Wording	Black

Procedures:

1. Introduce the students to a variety of maps. For example, maps that show:
   - towns and cities in detail for motorists (Road Maps)
   - elevations and surface configurations (Contour or Topographic Maps)
   - buildings, rooms or other physical features of a business (Facility Maps)
2. Choose a location outdoors that has a simple slope to it. (Note: If a slope is not available, an area with steps will work well also.) Begin by having the students investigate the area chosen. Explain that they will be making an accurate map of the area and all of the physical features in it. In order to make the map to scale for the area, have the students set up a grid system that they can use as their guide in surveying.
3. Start by staking out lines of yarn to serve as a border for your area. Next, create a grid by stringing the yarn across the area forming equal boxes covering the entire section. With the string grid as a guide, have the students draw a map of the area using lined paper in order to accurately replicate the physical features in each section.
4. The students may then add contour lines to their maps by starting with a point of known elevation and connecting it with a single line to the other points with that elevation on their grid. On the slopes or steps, have the students use the same grid measurements to note the incline by marking its elevations with other contour lines.

Variation:

- To illustrate the drainage course of a watershed, perform this activity on a plot of land that includes a stream or small waterway.

Watershed Discussion Questions:

- Why is it important to know the elevations of an area?
- How many different professions use maps regularly?

The Lay of the Land

Grades: middle and upper

Objective: to illustrate how ground composition and topography affect the rate of water seepage, runoff and reservoir formation

Subjects: Earth Science, Math, Social Studies

Materials: Several aluminum pans, a variety of soils, water, a measuring cup, a sprinkling can, clumps of grass or other vegetation, (optional: vegetable oil, food coloring, pieces of litter, one 4 foot board)

Information:

> "... The new creek bed is ditched straight as a ruler; it has been 'uncurled' by the county engineer to hurry the run-off. On the hill in the background are contoured strip-crops; they have been 'curled' by the erosion engineer to retard the run-off. The water must be confused by so much advice." - A Sand County Almanac, *Aldo Leopold*

Once your students have had opportunities to explore the permeability of different soils and observe the effects of water runoff on surfaces, the next logical step for them is to seek solutions to erosion and sedimentation problems. Before we make changes to an area, however we must first explore all of the options we have at hand. During the following activity, students will set up and test different soil's surfaces and topographies to monitor how these factors influence the quality and quantity of water runoff.

Procedures:

1. Have the students help in collecting equal quantities of different types of soils (sand, compost, loam, clay, etc.) and perform the following experiment. Spread and pat each sample firmly into the bottom of separate metal pans that will not leak water.

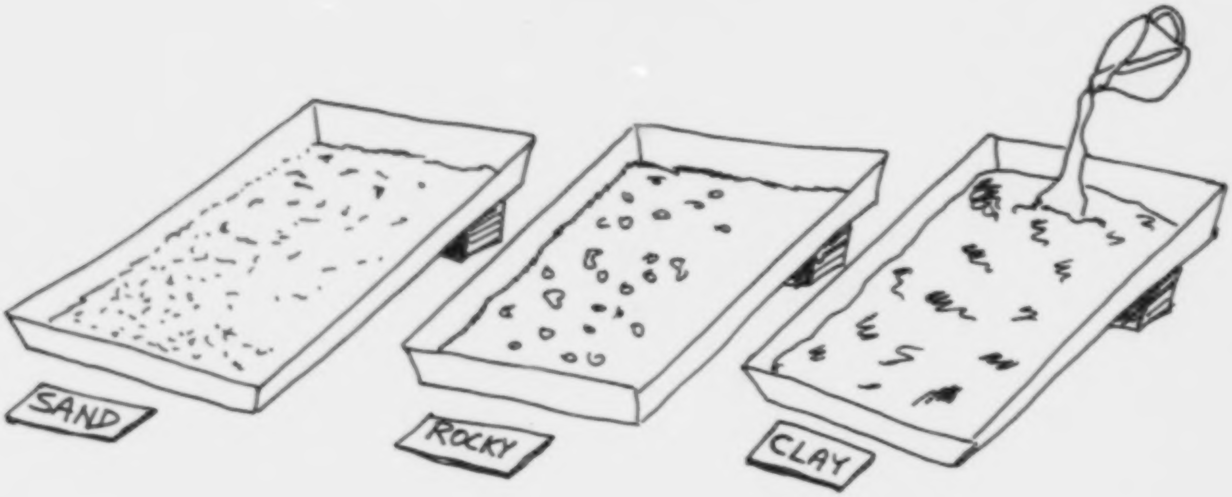
2. In setting up this experiment, choose an area that is either easily cleaned or outside. Begin by propping each pan up equally on one side creating mild inclines in the surface of the soils. (*Note: One long board under each of the pans' ends works well to insure the equal inclines.)

3. Using the measuring cup, record how much water you put into a sprinkling can. Sprinkle water on each sample one at a time, slowly enough so that it does not make gullies. Observe which soils will hold the most water before it begins to pool at the bottom. Record each of the results. How much water can each hold before runoff occurs? How long does it take for the water to pool in each sample?

4. Have the students collect additional samples of the soils. Perform the experiment again with the fresh collections, this time varying some of the variables in the surfaces. Make the hills larger, create bumps and ridges, add strips of vegetation and/or pour the water in a more rapid stream. Record each of the results. What path is the water taking, i.e. straight, meandering, etc.? At what point does the soil begin to erode in each sample? In what areas are the effects of erosion more pronounced?

5. "Pave over" some of the land by using plastic wrap laid on the surface. Add water and see what happens. You have just created stormwater runoff from a typical city area. Record the results. Add substances that represent pollutants to your landscape (a few drops of cooking oil, food coloring, pieces of Styrofoam, etc.) Record the results of these additions. Where does the runoff take these substances?

6. Discuss with the group all of their findings. Continue the discussion to include how each person's daily activities can affect the quality and quantity of water runoff.



Variations:

- In demonstrating the ability for vegetation to hinder the erosional effects of water runoff, place strips of grass across the hillsides and record the results. Also note the efficiency of adding contour plowing rows in the soil.
- To illustrate how groundwater contributes to surface water, create a land formation in your pan with water permeable soils so that it has all hills or high land on the sides with the center at a lower elevation. Sprinkle water on the sides allowing the water to seep in but not runoff. Observe how the reservoir will fill in without the addition of surface water runoff. In demonstrating how surface pollutants may enter a reservoir through seepage or surface runoff, add the food coloring or vegetable oil to the surface of the soil before watering. Record and discuss the results.

Watershed Discussion Questions:

- What pollutants might be found in urban runoff? Where do they come from?
- What pollutants might be found in rural runoff? Where do they come from?
- Which of your daily actions might cause pollution to a nearby water supply?
- What can you do to decrease pollution to water areas near your home?

Sources: Activities adapted from *Ideas for Teaching About Runoff* in NYS DEC's activity sheet, *Municipal Waste Contamination* in Groundwater Activities and *Landform Model Alternatives* in All About Water

Pump It Up

Grades: middle and upper
Objective: to illustrate the movement of groundwater through soils
Subjects: Earth Science, Social Studies, Health

Materials: 2 liter clear plastic containers, pump sprayers from a bottle of all-purpose cleaner, small pieces of nylon fabric, masking tape or rubber bands, scissors, transparent straws, small rocks, clean sand, food coloring, spray container with water, disposable water syringe

Information:

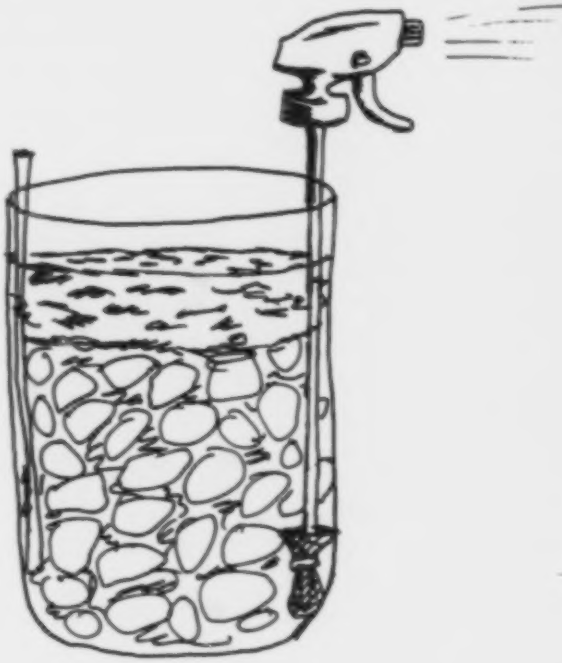
"It is not until the well runs dry, that we know the worth of water." - *Benjamin Franklin*

It is said that at any given time, the world's streams contain more than 300 cubic miles of water. The volume of the world's fresh-water lakes is one hundred times that with nearly 30,000 cubic miles of water. Even this amount pales in comparison to the amount in the world's groundwater which is estimated to be 1,000,000 cubic miles of water. However, only a fraction of this underground reservoir can be actually be tapped and made available to us on a perennial basis through wells and springs. (*U.S. Geological Survey*) These are important points when you consider the fact that up to 80% of the Catskill Watersheds' residents use groundwater for their water supplies. (*NYC DEP*)

This flow model will help students visualize the movement of water through the ground recording the processes of tapping an underground reservoir and the effects of contamination of these resources.

Procedures:

1. Begin by having groups of students follow the directions for making a flow model.
    A. Secure a piece of nylon over the end of the pump sprayer with masking tape or a rubber band. The nylon will act as a pump screen.
    B. Cut the top off of a plastic 2 liter container.
    C. Fill the container approximately one-third full with small rocks.
    D. Insert the pump sprayer into the rocks and hold it vertically near the side of the bottle while filling the container with sand to within two inches from the top.
    E. Insert a straw into the sand near the outside of the container opposite the pump sprayer.



2. Add water slowly to the containers to saturate the sand and rocks. Observe the water table in each and discuss how the addition of precipitation affects the level of a water table. The sprayers represent wells which will be operated to utilize the groundwater.
3. Use the pump sprayer to withdraw water from the flow model. During pumping, observe the dip in water level around the well. This is known as the cone of depression. It will gradually fill back in with water after the pumping stops. Observe and record how the well is able to affect the level of the water table.
4. Draw the water level below the surface of the sand. Spill some "pollutant" (food coloring) on the top of the sand. Use the well pump to withdraw water from the model and observe any movement in the pollutant.
5. Spray water on the sand to simulate rain and draw water from the model with the pump. Observe and record the difference in the action of the pollutant when the chemical comes in contact with the water.
6. Next, add food coloring into the straw using a syringe of water and inject the pollutant into the top layer of water in the sand. Use the well pump to withdraw water from the model and observe and record the movement of this pollutant through the groundwater.
7. Take this opportunity to discuss the dynamics of aquifers and the process and time necessary to clean any contaminated underground waters.

Variations:

- Investigate how different soils influence the rate of groundwater flow by replacing the sand and rocks in the flow model with clay or other types of soil.
- Discover how much water different materials will hold by performing the following experiment. Begin with several containers holding the same amounts of different soil materials. Pour known quantities of water into each of the materials measuring the amounts the soils are able to absorb. This experiment will help students discover the soils beneficial for groundwater supplies. For example, sand is ideal to get groundwater from because it holds water more than gravel, and also allows the water to flow faster than in clay.
- Further explore how water runoff from urban or rural communities can affect groundwater and well use by adding this set up to the landform models in this guide's activity The Lay of the Land.

Watershed Discussion Questions:

- Name something in your community that may contaminate your groundwater supplies (i.e. landfills, stormdrain runoff).
- What would a community do if their groundwater became undrinkable? To find out what New York City did when it was in that situation, see *From Wells to Watersheds.*

Source: Adapted from *Groundwater Flow Model - 2 Liter* in A Hidden Treasure

The Trouble With Turbidity

Grades: middle and upper
Objective: to measure the amount of turbidity caused by materials suspended in water
Subjects: Earth and Life Science, Chemistry, Social Studies, Health

Materials: Black Paper (2 sheets), a large glass jar, a flashlight, water, silt or fine dirt

Information:

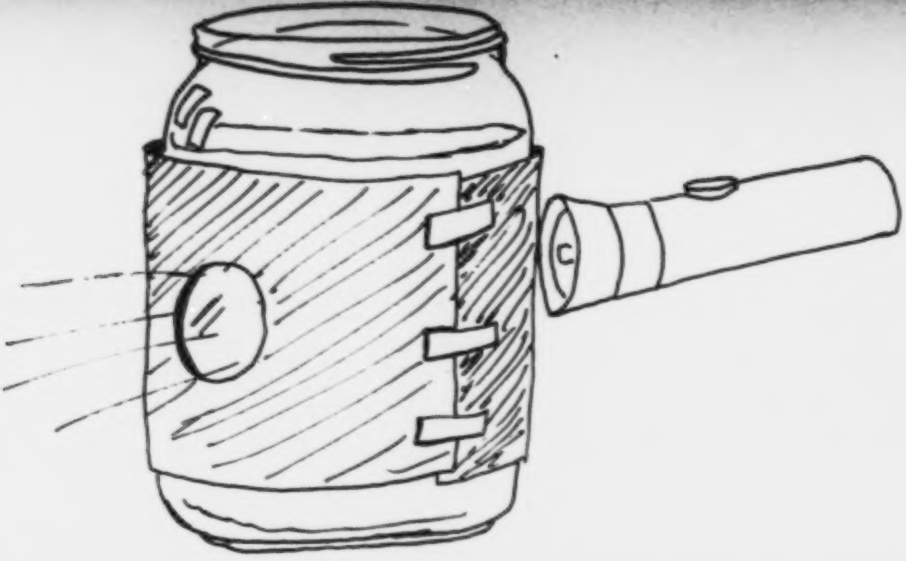
Water's ability to dissolve just about any substance given the proper conditions and enough time has earned it the title of "universal solvent". Understanding the dynamics of substances dissolving in water can lead a student to a world of comprehension in subjects including drinking water potability, aquatic animal respiration and plant photosynthesis.

Water pollutants that are not fully dissolved in water are instead suspended, or buoyant, in the solution. The stirring of heavy sediment or foreign particles in a solution is referred to as turbidity. If some materials, like silt, are suspended in moderate amounts in water, the particles may actually serve as substrates or foundations upon which bacteria or other pathogens may remain dispersed throughout a water column for lengthy periods of time. Suspended particles may also form physical barriers preventing light from reaching aquatic plants below the surface and/or curtailing the flow of oxygenated water through the respiratory devices of gill-breathing animals. If suspended particles carrying nutrients such as nitrates or phosphates settle out of water runoff, they may cause physical, chemical and even biological changes in a lake, estuary or slow-flowing stream.

Whether sediments are affecting the capacity of the reservoirs to hold water or the potability of our drinking water, suspension of substances in water is a concern to be explored. The following activity will encourage students to investigate turbidity in water solutions and gain an understanding of the critical difference between dissolved and suspended substances.

Procedures:

1. This experiment is set up to demonstrate how you can measure the amount of turbidity in water by measuring the amount of light penetration through the solution. Begin by cutting a series of concentric circles in a sheet of black paper. Next, cut a hole in the paper so that when it is wrapped around a glass jar, the circles and the hole will be opposite each other.
2. Wrap the paper around a jar and secure it in place.
3. Fill the jar 3/4 full with clean water.
4. Shine the beam of light from the flashlight through the holes in the paper. Observe and record the light intensity on another black sheet of paper.as the beam emerges from the jar. (*Note: To obtain a quantitative intensity measurement, use an inexpensive photographic light meter to check each of the samples. The meter may be within your school's photography or science departments.
5. Add silt to the jar of water, shaking the jar to keep it in suspension.
6. Repeat step #4 and observe and record the reduction of light penetration through the jar. This could also be done in gradual steps, adding silt until it no longer dissolves and continuing until no light penetration is evident.



7. Take this time to discuss the students' findings. Discuss the relationship between the turbidity of a water solution and the lifeforms depending on the water source for survival.
8. When working in a field situation at a pond or lake, a Secchi Disk can be used to measure visibility in the water. To make your own equipment, take a metal disk such as the lid of a #10 can and drill a hole in the center of it. Paint the disk black and white for contrast. Attached the disk to an eyebolt and string through the center hole. Add a couple washers to the disk and bolt to provide some additional weight. Secure a heavy string to the eyebolt and mark it at 1-foot intervals.
9. When using the disk, lower it into the water until it disappears. Take a depth reading at that point. Then, let the disk sink a few feet further. Next, raise the disk slowly until it becomes visible once again. Take a depth reading at this point. Average the two readings. This figure is called your limit of visibility.

Variations:

- In comparing and contrasting the effects of different materials on the amount of turbidity, perform this experiment with different weights of soil particles (i.e. silt, sand, clay, etc.)
- In measuring the effects of salt quantities on the photoavailability in saline solutions, measure the turbidity of different saltwater concentrations.
- In demonstrating the effects of pollutants found in community runoff on a water column, add common pollutants that would wash off of streets or fields (i.e. litter, oils, chemicals) and compare the amount of available light through a solution. (*Note: Take care to dispose of these particular pollutants in the appropriate manner.)

Watershed Discussion Questions:

- What are some natural causes of high turbidity in a waterway?
- What are some ways in which we can slow the amount of sedimentation entering a waterway?
- What can you do to make a glass of turbid water potable or safe to drink?

Source: Adapted from *Dissolved or Suspended?* in My World, My Water and Me: Teacher's Guide

The Geology of the Watersheds
Assessment Tools

Journal Writing

"A man may write at anytime if he will set himself doggedly to it."
- *Samuel Johnson*

Student reflection in journal writings motivates them to record their thoughts about a lesson as well as helps the teacher assess the status of the students' skills and understanding of the subject. The questions posed in the sections of a journal may have different emphases depending on the age and abilities of the students. Carefully chosen questions can facilitate the students' development in various levels of understanding from the knowledge of the facts to the comprehension and application of the materials and even the opportunity to analyze, synthesize and evaluate the concepts the students have learned. The following are some suggested categories and questions for student journals on the subject of Soils and Water.

Knowledge of the subject:

Definitions
  What does the word erosion mean?

Descriptions
  Describe the layers of soil you may find in your schoolyard.

Comprehension of Subject:

  Describe in your own words how the Catskill Mountains were formed.

Application of Knowledge:

Relations and Examples
  How are the Catskills related to the Acadian Mountains?
  How are the Catkills an example of the effects of erosion from water?

Analysis Skills:

Compare and Contrast
  Compare and contrast the Catskills with the Rocky Mountains?

List Evidence
  What are some of the causes of soil erosion in an urban area?

Synthesis Skills:

What may happen if a company were to build a housing development on a steep incline in the Catskills? What solutions do you suggest?

Evaluation Skills:

What is the most important thing an individual should know about soils when looking for a source of drinking water?

The Geology of the Watersheds

Class Follow-up Projects

If, after this section on The Geology of the Watersheds, the class is eager to build on these lessons, incorporate a few successful follow-up projects on the subject.

Researching Geology:

- Have the students research and make a collection of the different types of rocks and associated soils commonly found in your area. Compare their collection with rocks commonly found in another part of the state or country. Compare the soils to see how the different rocks effect the soil development.

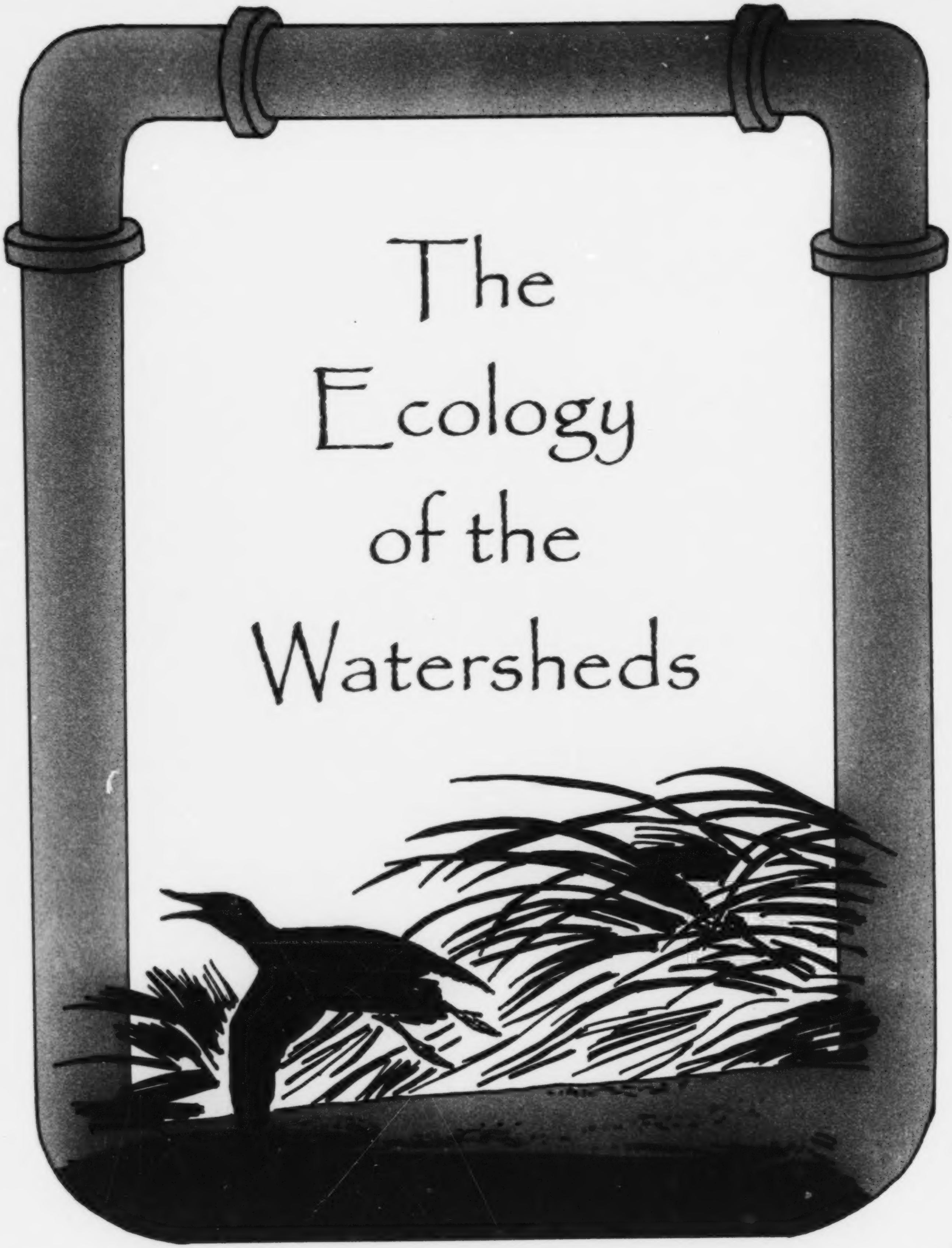
Making Soils:

- Encourage the students to make composters for your school and/or their home wastes. Use the students' compost to create a garden or other beautification projects for the school and community.

Community Action:

- Develop a task force of students to seek out sites of water erosion in their community and work on solutions to the situations.
- Develop a task force of students to identify sites of groundwater supplies in their area and seek out any possible treats to the quality or quantity of those reservoirs.

The Ecology of the Watersheds



The Ecology of the Watersheds

This section of our guide includes the following:

- information inserts - - on the subjects of species interdependence and the Catskill Mountain ecology
- a variety of activities exploring topics in aquatic ecosystems, adaptations of their inhabitants and how these dynamics affect the ways of the watersheds

Ecology - The Study of Homes

Water Walk
to explore the many ways in which people and other living things use water

River Sticks
to provide an opportunity for listening to and reflecting on the movement of water

Earthlings
to investigate how soil organisms enhance soil structure and fertility

The Flora and Fauna of the Catskill Mountains

A Little Link in the Food Chain
to become familiar with a seemingly insignificant aquatic organism and become aware of its important role in a freshwater environment

Is That Me?
to introduce students to the different organisms found in a freshwater environment

Creature Creations
to explore aquatic animal and plant adaptations

Camouflage!
to illustrate the effects of adaptive coloration on species survival

Pond and Stream Exploration
to investigate the biological, chemical and physical characteristics of aquatic habitats
The Biological Characteristics of an Aquatic Environment
Catching and Collecting Aquatic Organisms
Making Your Own Collecting Equipment
The Chemical and Physical Characteristics of an Aquatic Environment
Dissolved Oxygen - Acidity - Water Depth - Water Temperature - Current Speed

Assessment Tools

Class Follow-up Projects

Ecology

The Study of Homes

Ecology - from the Latin *Eco* meaning "home" and *ology* meaning "the study of"

The word **ecology** is often defined as the study of the interactions of living organisms with one another and with their nonliving environment of matter and energy. Any way you look at it, studying the ecology of an area means studying the homes and life histories of the plants and animals present. To comprehend the role of water in providing a suitable physical, chemical and biological environment for all organisms, let us first examine some of the terms associated with the topic of ecology.

Ecological studies deal mainly with the interactions among organisms, populations, ecosystems and the ecosphere. The term **organism** describes a living individual plant or animal. They are often classified into **species** which are groups that resemble one another in appearance, behavior, chemistry, and genetic structure. Scientists estimate that there are anywhere from 5 million to 100 million species existing on earth today. So far biologists have been able to identify only about 1.4 million of these species. It is often said that we know a fair amount about roughly one-third of the species in the world and the detailed roles and interactions of only a few of them.

A **population** is a group of individuals of the same species occupying a given area at the same time. Some examples would be: White pine trees in a forest, Bull frogs in a pond, or people in a country. Genetic diversity happens in most natural populations, which explains why individuals of the same species often do not all look or behave exactly alike.

The place where a species is known to live naturally is a **habitat**. Populations of all of the different species in a specific area make up the area's **biological community**. Taking that definition one step further, an **ecosystem** is a community of different species involved in a dynamic network of biological, chemical, and physical interactions that sustain it and allow it to respond to changing conditions. Sizes of ecosystems vary. Together, all of the earth's ecosystems make up our **ecosphere**.

The health of Earth's ecosphere is dependent on the variety of organisms available through genetic diversity, species diversity (the variety of species on earth and in different habitats), and the ecological diversity (the variety of forests, deserts, grasslands, streams, and other biological communities that interact with one another and with their nonliving environments).

To truly understand how water is a necessary component in ecosystems and to the existence of all living things, we may start by exploring water's influence on the many varieties of environments from the most arid conditions in some soils to the very wet world of a pond. The following activities will guide your students through investigations into the subjects of water and ecology, exploring topics in habitats, food chains, animal and plant adaptations and aquatic ecosystems.

Water Walk

Grades: elementary
Objective: to explore the many ways in which people and other living things use water
Subjects: Earth and Life Sciences, Social Studies

Materials: Paper and pencils for each student

Information:

"The joys of exploration are as varied as the numbers and characters of the explorers themselves, and the joys change during the lifetime of each person." - *Charles William Beebe*

We as humans need and use water in a wide variety of ways throughout our lives from nutrition to industry to transportation. Many students do not realize the importance of water in our lives as well as in the other lifeforms with which we share the planet's water. An adult human can live for approximately one month without food, but only a few days to a week without drinking water. We need water for every system in our body. Water makes up 83% of our blood and approximately 70% of our brain. Water helps us digest our food and keeps our bodies cool.

All plants and other animals also need water. Some desert plants have huge root systems that utilize every ounce of water in meager water supplies available to them. Animals living in saltwater have special filtration systems in their bodies that separate out the salt from the water. Water is one thing we all have in common. Every living thing needs water to survive.

Procedures:

1. Have the students list all of the ways that people use water. Ask them to then rank the ten most important water uses and state why their first choice is the most important.
2. Take the students for a walk around the school building and grounds and ask them to look for other uses of water in action. Instruct the students to add the uses they find to their current list.
3. When the lists are completed, discuss their findings. Add all of the different organisms they found that were using water in the area (i.e. kids, plants, birds). Talk about any examples of water being wasted in the area (i.e. dripping faucets, students allowing the drinking faucet to run while they talk).

Variation:

- Do this activity in a variety of environments (inside the school, out in a field) then compare and contrast how water is being used in each location.

Watershed Discussion Questions:

- How is water used in New York City? in the Catskill Watersheds?
- Why is water important to both the Catskill community and New York City residents?
- What water uses do you have in common with someone in another community?

Source: Adapted from The Story of Drinking Water, by permission. Copyright © 1990, American Water Works Association.

River Sticks

Grades: all grades
Objective: to provide an opportunity for listening to and reflecting on water's movement
Subjects: Earth Science, Music, Language Arts

Materials: A medium-sized stick for each student, a waterway of any size

Information:

"...The pipes no longer sound as often or as clearly as they once did, but I know they are there and that children still hear them. I can tell by the light in their eyes, the sudden catch in their voices, by the constant listening and awareness of things that may be lost to me."
- *Sigurd F. Olson*

This activity is a simple sensory lesson that opens a whole new perception of the world of running water for the students. By listening to a flowing river with river sticks, the students will be able to hear the force and power of even the smallest currents.

Procedures:

1. Begin by taking your students to an area with a running waterway, i.e. a stream, river, curb by a storm drain.
2. Give each student a stick and explain that the sticks can be used to transport the sounds (vibrations) of the water up to their ears.
3. Encourage the students to place one end of their sticks in the water and touch the other to their ear. Now listen.
4. Give the group the freedom to listen to a variety of places and compare the sounds. If the water is not flowing at your location, try listening to the water while someone taps on the surface of the water or try this with the miniature waterfall produced by a faucet.
5. Ask the students to write down a description of the sounds that they heard in each place. Encourage the group to share their findings.

Variation:

- You can also use a "Hang-o-phone" to listen to the water. In order to make a hang-o-phone, take a wire hanger and hold it upside-down. Tie one 12 inch piece of string to each side of the long wire of the hanger. Holding each end of the strings to each of your ears, lower the hanger into the water and listen. The vibrations will travel up the wire and strings and allow you to hear the water movement. Try comparing the sound of water movement to the sound created when you tap the hang-o-phone on a hard surface.

Watershed Discussion Questions:

- What does the sound you heard from the water remind you of?
- Many people use the sound of water to relax. How does the sound make you feel?
- Name some natural areas where you can hear running water. Name some areas in a city in which you can hear the sounds of water running.

Earthlings

Grades: elementary and middle
Objective: to investigate how soil organisms enhance soil structure and fertility
Subjects: Earth and Life Sciences, Social Studies

Materials: Clumps of soil approximately 6″ x 6″ x 6″ (select soils from different locations: woodland, lawn, marsh, including an inorganic sample such as baseball diamond soil), trowels, spoons, magnifying glasses, containers (jars, coffee cans, milk cartons, etc.), pencils and paper, field/identification guides, microscopes (optional)

Information:

"Below that thin layer comprising the delicate organism known as soil is a planet as lifeless as the moon.." - *G.Y. Jacks & R.O. Whyte*

Soils provide a variety of habitats for plant and animal life. Differences in soils influence the variety of organisms which can exist in a certain location. To some extent, plants and animals also influence the conditions of soils. One example is how Earthworms enrich the soil by digesting decaying leaves. Earthworms are also noted for improving soil aeration by creating a series of underground tunnels as they travel through the soil. While investigating the ecology of soils, you will find that many of the interrelationships are very complex and are not completely understood. Expect some unanswerable questions and a lot of curiosity.

Procedures:

1. Begin with a discussion of the characteristics and ecology of soils.
2. Next, divide the students into investigation groups of 4 - 6 individuals each.
3. Give each group a large clump of soil and the materials needed to set up a study station (trowels, spoons, containers, magnifying glasses, paper and pencil, etc.).
4. Working as a team, each group should then begin to carefully pick apart their clump of soil. During their investigations, encourage the teams to explore and record the soil characteristics (color, moisture, texture, looseness, etc.), evidence of decaying plants (leaf bits, rotted wood, etc.), evidence of animals (burrows, shells, skeletons), and the number and types of the plants and animals found. Living animals which are discovered should be carefully placed into containers for further study.
5. Upon completion of their investigations, compare and contrast the findings of each group.
6. Continue with a discussion on the organisms found. What do these soil animals eat? Are there differences in the types and abundance of the animals found? What accounts for these differences? Using mathematics, how can we estimate the number of earthworms (for example) that are present in the schoolyard? Can you find some even smaller (microscopic) organisms in the soils?
7. At the conclusion of this activity, special care should be taken to return the organisms to their original habitats and homes. Involve the students in these releases directing them to find the appropriate locations in which these plants and animals should be set free.

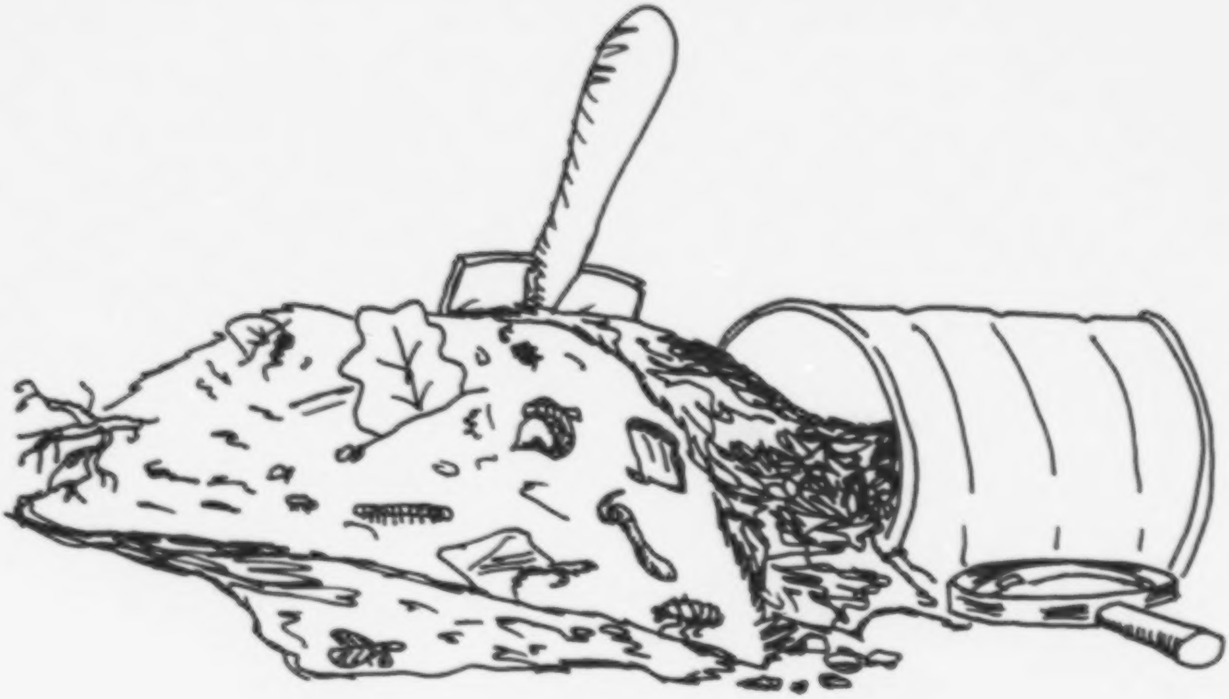
Variations and Watershed Discussion Questions:

- As an extension of the above activity, have the students try to rebuild the clump of soil that has been taken apart. Can it be put back together to the same condition it was before? What important things will now be missing from the soil? (worm tunnels, home spots, etc.) How does this relate to the world as a whole?

- Have your students think of ways they might improve the inorganic soil sample. What types of things are needed to make it habitable for soil organisms? Encourage your students to build a terrarium using the inorganic soil to judge their results of trying to enrich the soil.

- Have the students research the life histories of some of the soil organisms they discovered during their investigations of the clump of soil. What role do these organisms play in the ecosystem? Why are they important? What factors could cause soil organisms to disappear? What would happen to the soil if these organisms suddenly disappeared?

Source: Adapted from *Earthly Inhabitants* in Land and Soil



The Flora and Fauna of the Catskill Mountains

The Forest of the Catskills

> "The mountains which traverse it, and impart to it its severe northern climate, belong properly to the Catskill range. On some maps of the State they are called the Pine Mountains, though with obvious local impropriety, as pine, so far as I have observed, is nowhere found upon them. 'Birch Mountains' would be a more characteristic name, as on their summits birch is the prevailing tree. They are the natural home of the black and yellow birch, which grow here to unusual size. On their sides beech and maple abound; while, mantling their lower slopes and darkening the valleys, hemlock formerly enticed the lumberman and tanner." - *John Burroughs*, 1904

The Catskill Mountains of New York State are in a region in which the natural environment has seen a great deal of change in the last 150 years. The alterations to the flora and fauna of the area were due primarily to the settlement of people and their industries into the region dating back as far as before 1840. Before any major settlement into the area, the Catskill woodlands were primarily Eastern hemlock (*Tsuga canadensis*) climax forests. The principal industries of the area established in the 1840s were lumbering and the tanneries which stripped and peeled the hemlocks' bark for use in making tannic acid for tanning leather. The tannery method of peeling the trees and leaving the trunks to rot swept through the Catskill valleys and moderate elevations, depleted the massive hemlock forests as early as the 1890s. Today, just 21,000 to 25,000 acres of old growth Hemlock forest remain, and those are all in parcels under 6,500 acres each (Mike Kudish of Paul Smiths College). The recovering ecosystems are almost exclusively secondary forest growth to this day. They tend to be mixed forests which typically include Hemlock, Beech, Sugar maple, Red maple, Black cherry, White pine, Yellow birch, and Gray birch at low to mid elevations with Balsam fir trees at the higher locations. The midstorys are typically Striped maple and Blue beech with the shrub layer made up mostly of Raspberries. The dense canopy cover of these forests results in low light intensity on the forest floor, accounting for sparse groundcover and shade-loving ferns.

Throughout the Frost Valley area, the browsing pressure exerted by White-tailed deer has affected the regeneration of trees and the general health of the forest. As a result of the loss of mammalian predators, wolves, the region's deer population is almost entirely managed by human intervention. Other creatures that create dramatic consequences for the forests' health are the White-pine weevil (effecting Pines), and the Woolly adelgid (effecting Hemlocks). In addition, it is also suspected that acid deposition is a major contributor in the general decline of the canopy layer of the maples and some of the other species of trees.

The upper watersheds of the Catskills became a State "Forever Wild" preserve in 1870. Most of the lower areas are privately owned and are used for agricultural, recreational, or residential purposes. The valleys of the east and west branches of the Delaware River and the Schoharie River are primarily agricultural areas. The valleys of the Esopus Creek contain several villages and scattered residential areas. Anthropologic effects are least evident in the Rondout, Beaverkill, and Neversink valleys (includes Frost Valley) that possess low human populations and little industry.

The Animals of the Catskills

> "The instinct of animals, both predators and preyed upon, for waiting in vegetative blankness
> is beyond the patience of all but a few human beings.
> The spider at its web and the fawn motionless all day long in its grassy bed,
> except when its mother comes to suckle it swiftly,
> are characteristic of the whole animal world."
> *- J. Frank Dobie*

Throughout the year at Frost Valley, one can expect to find a variety of animal populations common to woodlands in the Northeast. Most likely due to the elevation and cool evening temperatures in every season, the invertebrates of this region are diverse yet moderate in population numbers. The fish species are limited by their food availability as well as their tolerance of the Catskills' generally fast-flowing and acidic waters. Fly fishing enthusiasts can expect to find Brook and Brown trout, Catfish, Bluegill, Minnows and others. Also typical to the Northeast, are the species of reptiles and amphibians found with a wide variety of snakes, turtles, salamanders, newts, frogs and toads. To highlight some of the birds of the area, most afternoons Turkey vultures, Red-tailed hawks, Ospreys, Broad-winged or Cooper's hawks and a rare Bald eagle soar overhead. Throughout the day, Crows, Ravens, Mourning doves as well as a variety of Woodpeckers and Sapsuckers busily search for food. During spring and early summer, hikers at twilight will hear an occasional Woodcock. In the evenings, the area's Owls call to each other. These night-hunters include the Great horned, Screech, Barred and Saw-whet owls. Great blue herons, Kingfishers, Red-winged blackbirds, Mergansers, Mallard and Wood ducks all make homes in the wetland areas. Great-crested flycatchers, Wood thrushes, Warblers and Scarlet tanagers are the prominent summer singers. Wild turkey, Ruffed and Short-tailed grouse are all important game birds of the area. The valley can also expect Evening grosbeaks, Cardinals, Nuthatches, Chickadees and other songbirds to visit the winter feeders.

Besides the White-tailed deer, the Frost Valley region is home to a variety of mammals. Skunks, Porcupines, Opossums, Chipmunks, Eastern cottontails, White-footed, Deer and Jumping mice, Beaver, Fishers, Woodrats, Short-tailed shrews, Woodland voles, Snowshoe hares, Woodchucks, Hoary and Little brown bats, Short and Long-tailed weasels, Minks, Muskrats, Coyotes, Bobcats, Raccoons as well as Gray, Red and Flying squirrels are all familiar. Visits from Gray and Red foxes are also becoming increasingly common. The most rare of all animal sightings are the Black bears whose habits usually keep them far from human contact.

Catskill Mountain White-tailed deer

A Little Link in the Food Chain

Grades: middle and upper
Objective: to investigate the important role of tiny animals in a freshwater ecosystem
Subjects: Earth and Life Sciences, Chemistry, Social Studies

Materials: *Daphnia*, pond water, large glass jars, aged tap water, sorting tray or cookie sheet with sides, petri dishes, hand lenses, eyedroppers, thermometers, paper, pencils

Information:

"All things by immortal power - Near and far - Hiddenly - To each other linked are, - That thou canst not stir a flower - Without troubling a star. - *Francis Thompson*

This activity is designed to open the student's eyes to some of the little known and seemingly insignificant yet very important interactions of an aquatic environment. While observing *Daphnia*, or water fleas, students will focus on their adaptive characteristics and their ecological niche or role of this species in an ecosystem. The niche of an organism includes all of the physical, chemical, and biological conditions a species needs in order to live and reproduce in an area. Once they have become familiar with the water flea and its environment, students can then use this knowledge to discuss the possible effects of human renovation of the Daphnia's pond habitat.

The Ways of the Water Flea

Daphnia pulex, also known as Water fleas, are small (1/16 to 1/8 inch) freshwater animals that are common in marshes, ponds and lakes. They are tiny relatives of crayfish, crabs, and lobsters and resemble their cousins although their exoskeleton (carapace) is very delicate and transparent. *Daphnia* occupy an important position in freshwater food chains by eating small organisms such as bacteria, protozoans, and Green algae. They swim by rapid jerks of their relatively large, two-branched antennae and can catch their food by moving their five bristly pairs of legs causing the food to flow through their carapace. The food is then filtered out of the water by the leg bristles as it passes toward the mouth.

Most *Daphnia* are female and can reproduce without fertilization. When the environmental conditions are favorable (abundant food and water, warm water temperatures), *Daphnia* populations are exclusively female. Eggs in groups of 10 to 20 develop quickly inside a brood pouch into tiny *Daphnia* and the live young are released within a few days. The young continue to grow rapidly and soon produce eggs of their own. Under adverse conditions such as cold temperatures or insufficient food supply, some males are produced. The males fertilize the eggs of the females and two dark capsules that each contain a fertilized egg appear in the female's brood pouch. The females release the capsules which are able to survive the low temperatures and dryness for many months. When the environmental conditions improve, the capsules break open and the eggs hatch into female *Daphnia*.

Another reason *Daphnia* are important to their food chain is that they are food for several predators including small fishes and Hydra. Also very small, a Hydra is a simple animal found clinging to water weeds in colonies. A Hydra's tube-shaped body sways in the water expanding and contracting searching for food to catch in the tentacles surrounding its mouth. An unfortunate creature that comes close enough to the Hydra will be stung and paralyzed by the tiny nettle cells covering the tentacles.

Procedures:

1. You can, if you wish, buy *Daphnia* from a tropical fish store or a commercial supplier such as: Carolina Biological Supply, Burlington, NC (800) 334-5551
   Frey Scientific, Mansfield, OH (419) 589-9905
   Ward's Natural Science Establishment, Rochester, NY (716) 359-2502

   You can also collect them from a freshwater pond and, if possible, involve the students in the process of obtaining the *Daphnia*.
2. To collect *Daphnia*, you will need a net and two large clean glass jars. Be sure that the jars are free of any soap residue. Fill one jar with pond water and pour this water through the net and into the other jar.
3. Next, empty the organic materials collected in the net onto a sorting tray or cookie sheet with sides. Using an eyedropper and a hand lens, select the largest Daphnia that have young in their brood pouches. (You should be able to see the brood pouches from underneath or from the back of the Daphnia.) Place the Daphnia and the organic material in the second jar containing the collected pond water. Continue adding Daphnia to the jar of pond water until you are sure that you have enough for the students to observe.
4. In order to observe the Daphnia, your students will need to transfer them from the large jars to the petri dishes using an eyedropper. Have aged tap water (water that has been sitting out for at least 24 hours) or extra pond water on hand to add to the petri dishes. Allow sufficient time for free observation.
5. Have students record their observations of the Daphnia's behaviors and adaptations. For example, note the way in which *Daphnia* move through the water, gather and store their food and a description of any eggs or brood pouches that they are able to find in the females. In what temperature of the pond water are the Water fleas most active? How do they think the Daphnia protect themselves from hydra and other predators? Ask the students to draw a picture of the Daphnia.
6. Discuss with the class their findings and talk about the Water fleas' position and importance to a freshwater food chain. Discuss the advantages to the Daphnia's method of reproduction and other adaptations that help them to survive. Ask the students to describe what might happen to the food chain if all of the *Daphnia* were killed off.

Variation:

- Investigate other animals and plants from an aquatic ecosystem (i.e. Algae, Hydra, Clam shrimp, etc.) and put together information on an entire freshwater food chain.

Watershed Discussion Questions:

Imagine that a family who lives near a freshwater pond decides to make it more desirable for swimming. They form a work crew and visit the pond on Saturdays, removing most of the aquatic plants, adding a layer of sand to the bottom, and grading a section of the shore to form a shallow slope for easy access to and from the pond.

- What are some of the possible effects of the pond renovations on the *Daphnia* and other pond life present?
- When should people draw the line when it comes to altering an aquatic habitat?
- How might we balance the needs of other organisms with the desires of people?

Source: Adapted from *The Ways of a Water Flea* in Water Wisdom

Is That Me?

Grades: all grades
Objective: to introduce students to the different organisms found in a freshwater habitat
Subjects: Earth and Life Sciences

Materials: Index cards with the names of aquatic organisms, tape, aquatic field guides

Information:

"The most apparent difference between animals and vegetables is that animals have the powers of sound and are locomotive, whereas vegetables are not able to shift themselves from the places where nature has planted them." - *William Bartram*

The freshwater environment is a world filled with a wide variety of plants and animals. The following activity is an interactive game which helps students get to know a few of the players in an aquatic environment.

Procedures:

1. After some discussion and possible exploration of a pond environment, explain to the students that you will be testing their knowledge of some of the aquatic plants and animals studied and found in those habitats.
2. Begin the activity by taping a card with the name and picture of an aquatic organism on it onto each student's back. Some examples of organisms would be:

   Algae
   Brook trout
   Bull frog
   Caddisfly
   Catfish
   Cattails
   Daphnia or Water flea
   Dragonfly nymph
   Duckweed
   Fern
   Hellgrammite (Dobsonfly)
   Hydra
   Iris
   Jewelweed
   Kingfisher
   Mayfly nymph
   Minnow
   Osprey
   Pitcher plant
   Predaceous diving beetle
   Red-spotted newt
   Rotifers
   Sedges
   Stonefly nymph
   Water lily
   Water parsnip
   Water penny

   Each student will be the organism that is printed on their back and it is their goal to find out who they are.
3. Instruct the students that they are able to ask the others in the group yes and no questions in order to find out who they are. For practice using an aquatic field guide, let the students use it for reference in answering their classmates' questions.
4. Once students have guessed their organism, they may take their sign off of their back and tape it to their front. They may then continue to help others by answering their classmates questions about their organisms. Once everyone has guessed who they are, have them line up in the order of a food chain or web using everyone present.

Watershed Discussion Questions:

- Which animals in the group are classified as invertebrates? And why?
- Which plants in the group are classified as vascular? And why?
- Which of these animals and plants live in your watershed?

Creature Creations

Grades: elementary and middle
Objective: to explore aquatic animal and plant adaptations
Subjects: Earth and Life Sciences, Art, Language Arts

Materials: Drawing paper and pencils, aquatic field guides (optional)

Information:

An adaptation is often defined as either a physical mutation or change that is beneficial to an organism and increases the survivability of its offspring or a change in the behavior of an individual or group in adjustment to new or modified surroundings. In either case, an adaptation is something about an individual organism that makes it better able to survive.

As we look at aquatic plants and animals, it is interesting to compare and contrast organisms from the still waters of a pond with ones from the rapidly flowing waters of a stream. This activity will ask students to use their imaginations and observation skills to create the perfectly adapted plants and animals for a variety of habitats.

Procedures:

1. After discussing a variety of freshwater habitats (i.e. streams, lakes, vernal ponds), explore the adaptations that organisms need to survive in these different locations.
2. Divide the class into groups of 3 students each. Give each group writing and drawing materials. Ask one group to create an animal that is perfectly adapted to live in a pond environment and draw a picture of it. This animal can be a combination of any creatures they choose. In addition to the picture, have the group name their creature and write a short description of the animal and its life history. Give each of the other groups the task of creating plants or animals from other environments (i.e. plants from a pond, animal from a vernal pond) After ample time, ask each group to present their creature to the class.
3. Compare and contrast the adaptations of each of the organisms and the conditions in their habitats that dictated those characteristics. A nice follow-up to this activity is the opportunity for the students to explore both a pond and a stream habitat and compare the actual organisms found in those locations.

Variations:

- For younger students, this activity can be done as a group with one person drawing the animal that the group creates together. For example: If you are creating a stream animal, start with questions like: How big should it be? What shape should it be? How many legs? Then go on to draw the animal as the students describe it. For older students, have them complete the description of the organism, fully outlining its reproductive cycle and its location in the food chain of that area.
- Once the animals have been created, pose the situation to the students that the habitat of their organism has been changed due to human intervention (i.e. a swimming area added to a pond or a dam in a stream). How does this change affect your organism?

Watershed Discussion Questions:

- If animals and plants are able to adapt to changes, why do some become extinct?
- What actions in your community affect the lives of the wildlife in your watershed?

Camouflage!

Grades: all grades
Objective: to illustrate the effects of adaptive coloration on a species survival
Subjects: Life Sciences

Materials: An open outdoor area suitable for running and playing hide and seek

Information:

The term camouflage is defined as "the method or result of concealing personnel or material from an enemy by making them appear to be part of the natural surroundings or a means of concealment or dissimulation (*The American Heritage Dictionary*)." For many animals and plants, camouflage means survival. Organisms that have adapted through time to blend in with their surroundings are better able to hide from their predators and stalk their prey.

The following activity is a very active game that illustrates the adaptation and art of camouflage.

Procedures:

1. Take your group to an open outdoor area that would be suitable for running and playing hide and seek. It should be safe to run at moderate speeds and also have things amongst which students would be able to hide.
2. The rules to this camouflage hide and seek game are:
   - The game begins when the leader shouts the word "camouflage!".
   - At that point, the leader will cover his/her eyes and count to fifty slowly.
   - The other participants should use this time to quickly find a place nearby that they can hide using camouflage. It is important that they do not hide completely behind some thing large. Some part of their clothing or body needs to be visible to the leader at all times.
   - When the leader is finished counting, he/she may look around for the others but may not move from his/her location.
   - As the others are found, they must come out from hiding and quietly join the leader.
   - When the leader has found all of the others he/she can locate, he/she must then count to fifty again without looking.
   - During this time, the remaining camouflagers should move closer to the leader and find another location to blend in and hide.
   - Again, the leader will find and call in all of the visible people.
   - When the leader has found all of the others he/she can locate, have him/her count to fifteen this time with open eyes. As the leader counts, the camouflaged students need to run in and tag the leader before he/she is finished. (*Note: It is important to stress that they should not run over the leader while trying to make the tag.)
   - The camouflager that makes it in on time becomes the leader for the next round.

3. After each round, discuss the colors and patterns that blend in well with each area as well as the locations that are easiest to hide in that particular habitat.
4. Compare and contrast the camouflage colorations animals and plants need for different locations. Some interesting animals to mention are Caddisfly larvae that build cases of materials from their environment in order to protect themselves and, on the opposite note, butterflies and frogs that are brightly colored for telling their predators that they taste bad or are poisonous.

Variations:

- Continue this activity throughout the class period with the leaders shouting camouflage in locations that they feel will be easiest to catch people (i.e. forests with little undergrowth, open lawns, the lunch room).
- Turn the tide and have one of the camouflagers shout the beginning of the activity when the group reaches a location in which it would be easy for them to blend in (a thick forest, fields with tall grasses). Later in the day, walk up to the students at their lunch table and shout "camouflage!". They should all be able to blend into the large student population quickly. This is a perfect opportunity to talk about flocks of birds and schools of fish and how they protect themselves.

Watershed Discussion Questions:

- If an animal is blending in perfectly with its surroundings, how does it attract the attention of a potential mate?
- During the industrial revolution in England, a native white moth adapted through time to the color of the soot-covered trees in order to hide from predators. Can you think of an example of an animal or plant that was not able to adapt to match a change that humans made to its habitat?

Pond and Stream Explorations

Grades: all grades
Objective: to investigate the biological, chemical, and physical characteristics of aquatic habitats
Subjects: Earth and Life Sciences, Chemistry, Math, Social Studies

"On a trip of exploration . . . there are three phases of interest and excitement - anticipation, realization and retrospection. . . But there is one single moment which is never quite duplicated. This is the moment when the first specimen is secured."
- *Charles William Beebe*

The following are a series of observation and exploration activities that will take your students into the aquatic worlds of pond and stream habitats and help them become acquainted with the biological, chemical and physical characteristics of these environments.

Biological Characteristics of an Aquatic Environment

Information:

The branch of biology that involves the systematic classification of living things is called taxonomy. Through time there have been numerous systems devised for grouping organisms according to their physical characteristics, evolutionary relations, and reproductive cycles. At one time, there were two major kingdoms of organisms classified - Plantae and Animalia. After some time, it was noted that the organisms grouped together in this way differed so greatly from each other that it seemed necessary that they should be distinguished as different kingdoms. Today, it is widely recognized that, based on the system first proposed by Robert H. Whittaker, organisms are divided into not two but five kingdoms. The kingdoms and their members are distinguished as follows: *Monera* (bacteria), *Protista* (including protozoans and algae), *Fungi* (molds and mushrooms), *Plantae* (flowering plants, conifers, ferns and mosses) and *Animalia* (animals with and without backbones). In some instances, organisms may be grouped into just three of the categories - *Monera, Plantae* and *Animalia* with *Protista* and *Fungi* falling into their prospective larger groups.

When exploring an aquatic environment, it is necessary to note the participation of members of all of the kingdoms in order to get a full picture of the dynamics of these complex ecosystems. An itemized list of many common organisms found in pond and stream habitats can be found in Appendix A of this guide. There are many excellent field guides and reference materials available for classifying organisms that students may find in an aquatic environment. Some worth adding to your reference materials are:

Pond and Brook:
A Guide to Nature
in Freshwater Environments
by Michael J. Caduto

Pond and Stream Safari:
A Guide to the Ecology
of Aquatic Invertebrates
by Karen Edelstein, Cornell Univ.

Golden Guide for Pond and Stream
by Western Publishing Company

Kid's Key to Catskill Creek Creatures:
A Dichotomous Key to the
Invertebrates of Catskill Creeks
by Tora Johnson, The Catskill Center

Catching & Collecting Aquatic Organisms

One way to get a closer look at the plants and animals that live in a water world is to catch or collect them. In order to preserve the habitat and ensure that the organisms are not hurt during your exploration, it is important to note that we are visitors to these water worlds and we should take care not to damage the surroundings or injure anything living there. For your safety and the safety of the aquatic organisms, it helps to know a little bit about the natural histories of the plants and animals that you may run across. Knowing how an animal defends itself or hides from predators will also help in the capture and observation of the creatures. **If you do take some plants and animals from their environment, be sure to return them to the same location and niche you found them in when you are finished.**

Making Your Own Collecting Equipment

A Dip Net

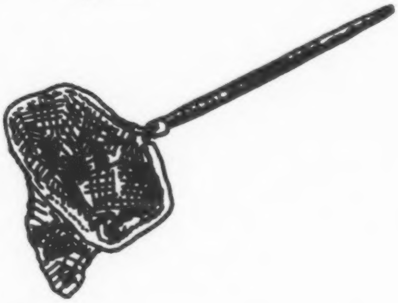
The dip net can be used to collect small to medium-sized plants and animals that are located beyond your reach. This net works well if you use a slow, gentle scooping motion. This action will catch a variety of organisms which you can then place into a light-colored container filled with water for easier observation.

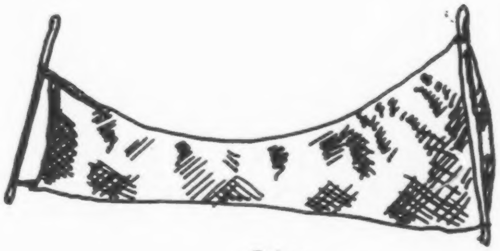
Materials: a wire coat hanger or heavy gage wire, waterproof tape, a wooden or aluminum pole, an old nylon stocking or a piece of mesh netting or burlap, a needle, thread

Assembly:

1. Bend the wire into an open circle.
2. Use the tape to attach the two ends of the wire circle to the pole.
3. Sew the stocking or net material to the wire to form a net.

Dip Net





Seine

A Seine

The seine net can be used to collect the variety of small to medium-sized plants and animals that are located in an area together. To use the seine, hold the two poles apart and upright so that the net is open but not tightly stretched. With the poles remaining upright, drag the seine through the water being careful to keep the weighted edge of the net on the bottom so that animals cannot escape underneath the seine. Work back to the water's edge and lift the net and your catch out and into a container of water for observation.

*Note: In creeks with high flows and rocky bottoms, it is often difficult to sweep a net through the water over the bottom surfaces where the bugs are clinging to the large materials. The "big dance" works best here. Hold the net stationary downstream and against the bottom of the creek. Stand upstream and very gently move your feet to scare the bugs from the rocks. Their flight is a predator avoidance behavior and will help you in sweeping them into the net. (*Tora Johnson,* The Catskill Center)

Materials: a piece of netting or screening 2 ft x 2 ft, two sturdy sticks or wooden poles about 30 inches long, a staple gun or string, eight 1-ounce fishing weights

Assembly:

1. Connect the opposite ends of the netting to each pole with staples or string making sure that the bottom of the netting is even with the bottom of the poles.
2. Attach the weights a few inches apart along the bottom of the netting.

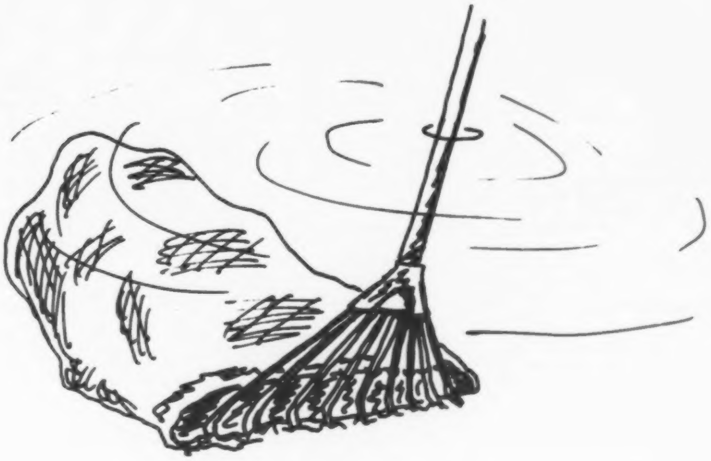
A Bottom Sampler

The bottom sampler works best for collecting organisms in mud, sand or gravel bottoms. This net works well if you drag the tines of the rake across the bottom in order to stir up any animals and plants living there. The organisms are then captured in the bag hanging behind the rake. Try to catch as little mud or sand in the net as possible. Then transfer the catch to a container of water for easier observation.

Materials: a piece of burlap or heavy netting, a needle and heavy thread, a metal-tined garden rake, string or fishing line (about 3 feet)

Assembly:

1. Sew the burlap or netting into a bag with an opening that just fits over the head of the rake.
2. Using the string or fishing line, attach the bag opening to the back of the rake head.



bottom sampler

Watershed Discussion Questions:

After using the collecting equipment that you have made to gather plants and animals from various water worlds, compare and contrast the different organisms found in the various locations with the different types of nets.

- What types of organisms does the dip net catch? The seine? The bottom sampler?
- Did you find the same organisms in the still waters of the pond that you found in the fast current of the stream? What were their different habitats like?
- Why is it important to return the organisms to the same location you found them in?

The Chemical & Physical Characteristics of an Aquatic Environment

Searching for organisms from a pond or stream environment is an interesting way to explore the adaptations and life histories of the inhabitants. Identifying the organisms found in a particular habitat may also provide some clues about the chemical and physical characteristics of the environments. We have already noted that ponds and streams differ in their populations of plants and animals, but it is the chemical and physical characteristics of these habitats that determine where an organism is able to survive. By first getting to know the native species or organisms that normally live and thrive in a particular ecosystem, we are able to correlate their presence with the typical aquatic conditions. By watching for the occurrence of **indicator species**, organisms that serve as an early warning that a community or an ecosystem is being degraded, we can again correlate variations in the chemical or physical characteristics of the environments and note any changes or effects on the habitat.

Dissolved Oxygen

All animals need oxygen in order to survive. The air we breathe is made up of approximately 20% oxygen. Organisms that live and breathe underwater are specially adapted to use the dissolved oxygen in water. Water tends to hold far less oxygen than air with only .00001% or 10 parts oxygen per million parts water. One part per million (ppm) is equivalent to one liter placed in a lake that has a surface area of a football field and a depth of 8.8 inches. There are several variables that can change the amount of dissolved oxygen in a body of water.

- Warmer waters tend to contain less oxygen than colder waters. Springs of groundwater add cold water nearly devoid of oxygen.
- Due to the production of oxygen from aquatic plants during the daytime, dissolved oxygen levels are highest in late afternoon and lowest just before sunrise.
- Water with higher levels of organic matter tends to have more respiration occurring through decomposition which causes lower levels of dissolved oxygen.
- Waters that are fast moving or windswept tend to mix more dissolved oxygen.

Measuring Dissolved Oxygen

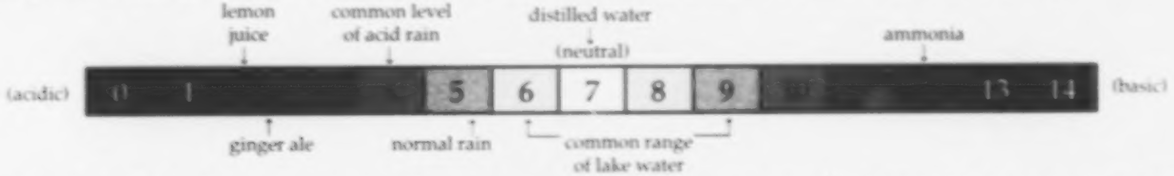
Immediately after getting a sample of water from your location, add 1 ml of manganese sulfate to a flask or bottle containing 100 ml of the water. Add 1 ml each of potassium hydroxide and potassium iodide. Stopper the flask and mix thoroughly. Add 1 ml of dilute sulfuric acid. Put the stopper back in the flask and mix the solution again. Let the water stand for 10 minutes. Add sodium thiosulfate to the water with an eye dropper, counting each drop added. Continue adding drops until a permanent color change appears. The amount of oxygen in your sample in parts per million = # of Sodium thiosulfate drops x 28.

You may also find the approximate amount of dissolved oxygen in a body of water by observing the organisms present. It makes a large difference to some insects whether they can get 4 ppm of oxygen or 12 ppm. This can make the difference between thriving or surviving. Indicator species for levels of dissolved oxygen are:

• High DO levels (8 - 10 ppm)	Stonefly nymphs, Water pennies, Caddisfly larvae
• Med. DO levels (4 - 8 ppm)	Damselfly and Dragonfly nymphs, many true bugs
• Low DO levels (0 - 4 ppm)	Mosquito larvae, Midge larvae, Tubifex worms

Acidity

Acidity is measured on a pH (potential Hydrogen) scale ranges from 1 to 14. The pH scale measures the strength of hydrogen ions in a solution. A reading of 7 on the scale is considered neutral. Readings below 7 indicate increasingly greater acidity with the decreasing numbers. Readings above 7 denote increasingly basic conditions. The pH scale is logarithmic, therefore, the increase or decrease of one number means a tenfold increase or decrease in acidity.


lemon juice
common level of acid rain
distilled water (neutral)
ammonia
(acidic)
0
1
5
6
7
8
9
10
13
14
(basic)
ginger ale
normal rain
common range of lake water

The level of acidity in an aquatic ecosystem has a very strong effect on which organisms are able to thrive and survive. Most lakes have a pH between 6 and 9 which is a range that is tolerable for many plants and animals. There are several natural as well as human-made causes for increased acidity in an environment. Areas with high acidity levels are often:

- areas with low buffering capacity
- areas with high levels of acid deposition and precipitation
- areas with naturally occurring bogs with *Sphagnum* present
- areas with acidic vegetation such as Hemlock Trees

The Catskill Mountain environments tend to have highly acidic waters due to their low buffering capacity and high amounts of acid precipitation. (For more info. on the effects of acidity on the environment, see this guide's *The Pollution Sources of the Watersheds* section.

Measuring Acidity

Using pH paper dipped into a fresh sample, compare the color of the pH paper with the colors on the measurement chart in the pH paper kit. In lieu of commercially bought blue litmus paper, students can make indicator paper using red cabbage. This is done by shredding the cabbage, boiling it for several minutes to extract a red liquid. After straining the contents, students may then use the liquid to dye white paper towels. They may then cut them into strips and use them as red litmus paper.

As with dissolved oxygen, you may also find the approximate amount of acidity of a body of water by observing the organisms present. Plants such as sedges, cotton grass, and some lichens can tolerate wet acid conditions yet most other rooted plants as well as algae prefer a pH range of 6.5-13. A good fish indicator for acidity are Daces. Long-nose and Black-nose daces, common fish in Catskill streams are usually not present in a body of water if the pH is low. Other fish that do not tolerate acidic water are trout. Brook trout begin to disappear when the pH of the water drops below 5, and Rainbow trout are affected if the pH dives below even the mildly acid level 6. Snails, Clams and Mussels all prefer the slightly basic waters of 7-9 pH. Many amphibians can tolerate mildly acidic waters with a Spotted salamander population being affected below a pH of 5.5, an American toad population being affected below a pH of 5 and the Wood frog population being affected only after the pH is below 4.5. The largest variety of aquatic insects prefer a range of 6.5-7.5 pH, so you can tell the pH is below 6 if the Mayflies, Caddisflies and Stoneflies are not present. All of these correlations explain why in the headwaters of the West Branch of the Neversink river where the pH is routinely measured with values 4, fish are not present though some species of acid-tolerant insects can be found.

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Water Depth

The water depth of an aquatic environment is important to the survival of the organisms that live there. Typically, as water gets deeper, the temperature generally gets colder and thus contains more dissolved oxygen. This explains why fish that require large amounts of D.O. move to the deep water during the summer when the surface water heats up. Plant life is also affected because the light energy they need for growth is less available in deeper waters.

Measuring Water Depth

There are several ways of measuring water depth depending on the distance being measured. If the water is shallow, you can use a yardstick to find its depth. A long stick can be used with a yardstick or tape measure to measure slightly deeper water. To measure the depth of deep water, you will need a depth gauge.

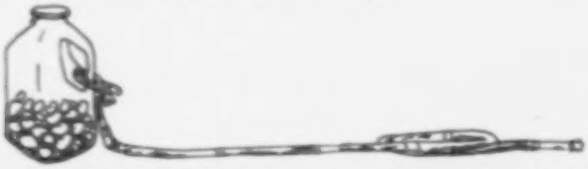
A Depth Gauge

A depth gauge is a weighted rope that has been calibrated to measure a distance. To use a depth gauge, you need to lower it into the deep water until it rests on the bottom and the line slackens. Then pull the line up gently to remove the slack. You may then determine the depth of the water from the marks on the rope.

Materials: a long rope (at least 12 feet), a weight (brick, anchor or plastic jug filled with sand or stones), waterproof markers (3 different colors), a tape measure or yardstick

Assembly:

1. Attach the rope to the weight. With the weight on the ground, have one student hold the rope straight up. Have another student measure 1 foot from the ground and mark that point on the rope.
2. Create a color code for marking the different lengths on the rope. For example: a black mark = 1 foot, a blue mark = 5 feet, a red mark = 10 feet, etc. Using your color code and tape measure, mark the rest of the rope.



As with chemical characteristics of a body of water, the physical characteristic of water depth can be estimated by the observation of the living organisms present. Water depth is a major factor in determining the plants present in a particular zone. Moving from the center, deeper area of a pond, one can often note as many as four different zones of plant growth. First, the **open or deep water zone** is dominated by planktonic algae with no sedimentary plant life able to grow at the light energy-starved bottom surface. The submergent zone with the depth of approximately 6.6 feet has little sunlight available for the submergent plants present. Submergent plants are those capable of growing completely underwater such as the Common elodea and Stonewort. One step closer to the shore is the **floating-leaved zone** which is shallow enough to host the emergent plants or plants that can tolerate flooded soil but not extended periods of time being completely submerged. These plants, such as White water lily and Floating pond weed, often keep many of their leaves as well as their flowers floating on the surface of the water. Just before and at the **shoreline** is the **emergent zone** which is home to more emergent plants like Jewelweed, Horsetail, Arrowhead and Sedges.

Water Temperature

The temperature of the water in an aquatic environment is also an important physical feature. How warm or cold the water is determines how fast many of the organisms present are able to grow. Most organisms grow quickly in warm water and slowly when the water is cold. Many animals living in water are cold-blooded, meaning that their bodies are the same temperature as the temperature of their surroundings and therefore are less active in colder waters. Temperature also affects the amount of oxygen the water is able to hold. Water temperatures may vary for many reasons which include water depth, shade, currents and springs.

Measuring Water Temperature

There are several ways of measuring water temperature depending on the depth of the water explored. If the water is shallow, you can use a weather thermometer tied to a string. Simply place the thermometer in the water for a few minutes and then read the temperature. A weighted thermometer is useful for measuring temperatures at a specific depth of water.

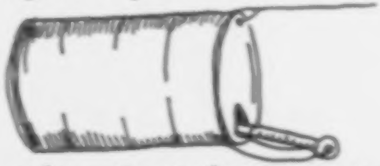
A Weighted Thermometer

A weighted thermometer may be lowered into deep water and left for several minutes. In this time, the can holding the thermometer will reach the same temperature as the surrounding waters. The thermometer may then be quickly brought up to the surface and read with its tip remaining in the can of water.

Materials: an empty soda can, sand or pebbles, a short piece of wire or string (about 10 in), a laboratory thermometer with an open loop at one end (must be able to read temperatures as low as 32°F or 0°C), a can opener, a long piece of sturdy string (at least 10 feet), a water proof marker, a tape measure

Assembly:

1. Put some sand or pebbles into the empty soda can so that it will sink in the water. Make holes in the top and sides of the can with the can opener. Pass the short piece of string or wire through the loop of the thermometer. Place the thermometer into the can and, passing the short piece of string or wire through one set of holes, tie or wire it securely to the can.
2. Tie one end of the long string securely to the can, passing it through the other set of holes. Calibrate the length of rope to determine the depth of water measured.



As with water depth, one can also estimate the temperature range of a certain body of water by observing the living organisms present . **Endotherms**, or warm-blooded animals, maintain a constant body temperature and are fairly independent of their environment. **Ectotherms**, or cold-blooded animals, must rely mostly on their environment to provide body heat. These animals have evolved a number of ways to control their body temperatures. Some creatures are **stenothermic** and have little tolerance to temperature changes. These animals seek out environments with fairly constant temperatures such as cool spring-fed streams. **Poikilothermic** animals, such as frogs, salamanders and newts, tend to have a broad tolerance to temperatures. These animals will often sun themselves in order to increase their body temperature and metabolic rate.

Current Speed

The movement of the water in an aquatic environment is an important physical feature when looking at the living organisms found in a freshwater ecosystem. Not all water is still. The waters in rivers and streams are often moving at different speeds in different locations. This movement is called a current. Currents affect the plants and animals living in aquatic ecosystems by shaping the topography, allowing for locomotion for some creatures, carrying food into the area as well as carrying wastes away.

Measuring Current Speed

By dropping an object into a stream and timing how long it takes to travel a certain distance, one can determine the speed of the current in that location. For more information on calculating stream flow, see *Gallons Per Minute*.

While studying the velocity and capacity of a stream's flow, it is interesting to note the aquatic creatures present and their adaptations for staying in place under such conditions. Some examples of adaptations and stream organisms that use them are:

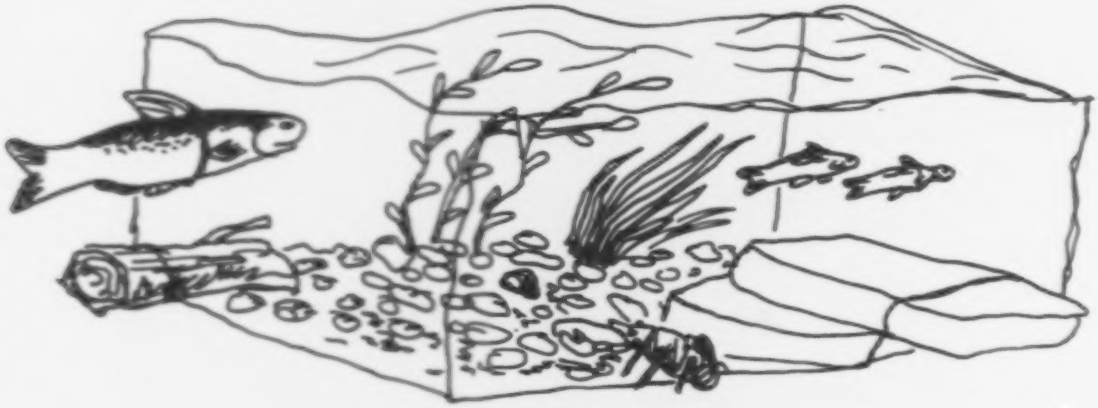
Flattening: to stay out of the current with flat bodies holding tight to surfaces (Water pennies, and some Mayfly and Stonefly nymphs)

Streamlining: to decrease resistance to the current as with fish and submerged leaves of plants (many Pondweeds)

Ballast: used by Caddisfly larvae that create their homes of heavy sand grains

Grasping Devices: includes suckers (Leeches, Snails), hooks, silk threads (Black fly larvae) and jelly (Snail egg masses)

Current Avoidance: such as hiding under rocks, moving into slower current and burrowing into sediment (many Salamanders and Newts)



Source: Equipment directions were adapted from *Biological Environment - Collecting Plants and Animals* in Water Worlds

The Ecology of the Watersheds

Assessment Tools

How Close To Extinction?

"To Homo Sapiens, which through the extinction of others endangers itself." - *Paul and Anne Ehrlich*

Investigating plants and animals through library research enables a student to explore every aspect of an organism's life history from its niche to its adaptations to its life and reproductive cycles. For an interesting perspective while studying specific organisms and their lives, encourage your students to choose an organism from the following list of endangered, threatened, and special concern plants and animals of New York State. Encourage each student to expand their view of the information available on their organism in order to hypothesize possible reasons for their organism's inclusion to these ominous lists.

Endangered, Threatened, and Special Concern Animal Wildlife Species of New York State

Endangered: native species in imminent danger of extirpation or extinction in New York

- • Chittenango Ovate Amber Snail
- * Dwarf Wedge Mussel
- * Karner Blue Butterfly
- Δ* American Burying Beetle
- * Shortnose Sturgeon
- Round Whitefish
- Pugnose Shiner
- Eastern Sand Darter
- Bluebreast Darter
- Gilt Darter
- Δ Spoonhead Sculpin
- Δ Deepwater Sculpin
- Tiger Salamander
- Bog Turtle
- * Leatherback Sea Turtle
- * Hawksbill Sea Turtle
- * Atlantic Ridley Sea Turtle
- Massasauga
- Δ Golden Eagle
- * Bald Eagle
- * Peregrine Falcon
- Δ* Eskimo Curlew
- •* Piping Plover
- Least Tern
- * Roseate Tern
- Loggerhead Shrike
- * Indiana Bat
- * Sperm Whale
- * Sei Whale
- * Finback Whale
- * Blue Whale
- * Humpback Whale
- * Right Whale
- Δ* Gray Wolf
- Δ* Cougar
- Δ Eastern Woodrat

Threatened:

native species likely to become an endangered species within the foreseeable future in NYS

Δ• Northeastern Beach Tiger Beetle
Lake Sturgeon
Mooneye
Lake Chubsucker
Mud Sunfish
Longear Sunfish
Cricket Frog
Mud Turtle
Blanding's Turtle
• Loggerhead Sea Turtle
• Green Sea Turtle
Timber Rattlesnake
Osprey
Red-shouldered Hawk
Northern Harrier
Spruce Grouse
Common Tern

Special Concern:

native species for which a welfare concern or risk of endangerment has been documented

Buckmoth
Silver Chub
Bravel Chub
Blackchin Shiner
Black Redhorse
Banded Sunfish
Longhead Darter
Southern Leopard Frog
Hellbender
Jefferson Salamander
Blue-spotted Salamander
Spotted Salamander
Spotted Turtle
Wood Turtle
Diamondback Terrapin
Worm Snake
Eastern Hognose Snake
Common Loon
Least Bittern
Cooper's Hawk
Black Rail
Upland Sandpiper
Black Tern
Common Barn Owl
Short-eared Owl
Common Nighthawk
Common Raven
Sedge Wren
Eastern Bluebird
Henslow Sparrow
Grasshopper Sparrow
Vesper Sparrow
Small-footed Bat
New England Cottontail
Harbor Porpoise

* Indicates that the species is currently listed as "endangered" by the U.S. Department of the Interior
• Indicates that the species is currently listed as "threatened" by the U.S. Department of the Interior
Δ Species is no longer living in New York State

list effective (last promulgated in state regulation) August 3, 1987: last nonregulated revision, February 1993.

The Ecology of the Watersheds

Class Follow-up Projects

If after exploring this section the class is eager to build on these lessons, incorporate some exciting trips with related organizations or create a classroom project involving New York State wildlife. Some suggestions for these follow-ups would be:

Water Field Trips:

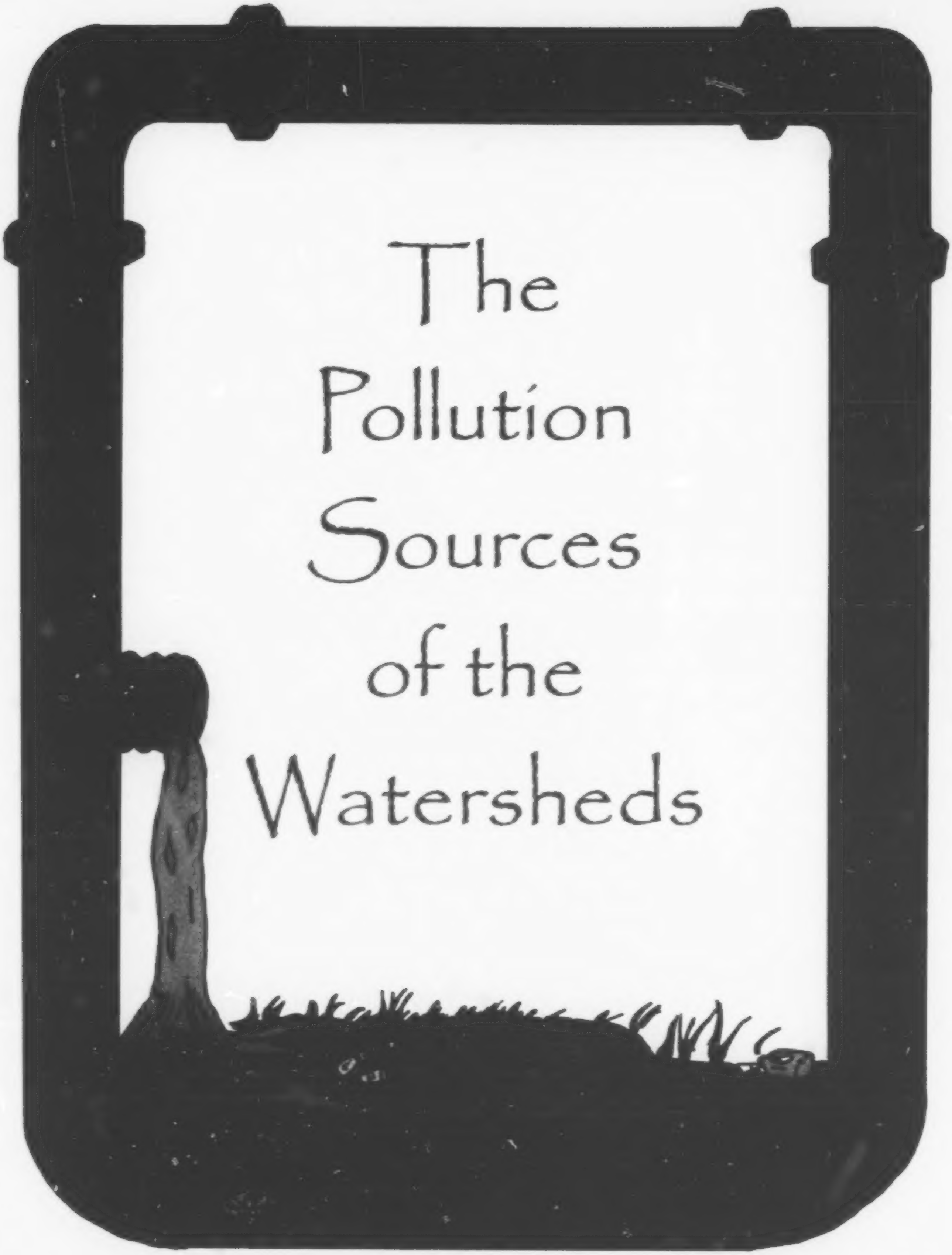
Visit and explore an outdoor water area or museum.
Some possible field trip locations for your school may be:

- **Exploring interactive environmental education** - A day or resident trip and outreach program with the Frost Valley YMCA's Environmental Education Center, Claryville, NY - For more information contact Frost Valley's Director of Environmental Education at (914) 985-2291.
- **Discovering NYC's ecology** - A day trip to the Central Park Conservancy's Education Programs, New York, NY - For more information, contact Jeffrey O'Handley, Science Education Specialist at (212) 315-0385.
- **Monitoring New York's aquatic ecosystems** - A day trip with the Catskill Center's Streamwatch Programs, Arkville, NY - For more information, contact their Program Associate at (914) 586-2611
- **Encountering New York's ecology** - A day trip to one of New York's State Parks - For more information, contact your regional office of NY State's Department of Environmental Conservation.
- **Diving into water programs** - A day program with your local Cornell Cooperative Extension - For more information, contact your local Cooperative Extension office.
- **Researching the wilds of New York** - A field trip to The American Museum of Natural History, Manhattan, NY - For more information, call (212) 769-5100.
- **Meeting New York's aquatic wildlife** - A field trip to New York's Aquarium For Wildlife Conservation - For more information, call (718) 265-3426.
- **Having fun with science** - A field trip to the Liberty Science Center, Jersey City, NJ - For more information, call (201) 200-1000.

Classroom Aquatics:

- After exploring an aquatic ecosystem, have the students carefully collect organisms for a classroom aquarium of that habitat. Caring for and maintaining the balance of an ecosystem close at hand will give them a unique perspective on the many dynamics of these complex environments.

The Pollution Sources of the Watersheds



The Pollution Sources of the Watersheds

This section of our guide includes the following:

- information inserts - - on the subjects of pollution sources, experimental methods, current research projects, toxins and pollution prevention
- a variety of activities exploring topics in water pollution, its sources and effects on the environment and how these dynamics affect the ways of the watersheds

Nonpoint Source Pollution

One In A Billion

to illustrate the magnitude of the concentration - parts per billion

Nonpoint Source Pollution On Stage

to investigate the causes of nonpoint source pollution, their effects on the environment and the ways in which pollution can be prevented

Washing Away

to demonstrate the causes of nonpoint source pollution and its effects on water quality

The Choice Is Yours

to exercise the decision-making skills involved in choosing a chemical pest control

In A Bind

to evaluate the harmful effects of litter in respect to wildlife

Oil Spill Emergency!

to simulate an oil disaster exploring clean-up procedures and consequences to wildlife

The Scientific Method

Finding Phosphorus

to measure the amounts of phosphorus found in a variety of water samples and discuss the potential problems created by these excess nutrients in an ecosystem

Too Much of a Good Thing

to explore the role of algae in an aquatic habitat and the impact of environmental changes to the balance of this producer and its ecosystems

The United States Geological Survey's
Water Quality Studies in the Catskills

Studying Acid Deposition

to investigate the causes and effects of this environmental concern
Patrolling Pollution
Pondering pH
Can Nature Cope?

Acid Rain Tag

to illustrate the effects of acidification of aquatic habitats on fish species

The Bioaccumulation of Toxins

The Great Debate

to weigh the social, environmental, and economic factors involved in solving the acid rain problem and make value judgments regarding the need for industrial controls

It All Adds Up

to illustrate the concept of biological amplification of toxins in an ecosystem

Catskill Community Solutions to Water Pollution

Picking A Place To Plant

to investigate the characteristics of healthy soils

Predacious Pesticides

to discover an chemical-free method of pest control

Treating Our Wastewaters

to explore two ways in which wastewater is treated

Assessment Tools

Class Follow-up Projects

Nonpoint Source Pollution

Pollution is defined as any addition to the air, water, soil, atmosphere or food that threatens the health, survival capability or activities of humans and other living organisms. Pollutants enter the environment either naturally (i.e. volcanic eruptions) or through human activities (i.e. from the burning of coal, spilling of chemicals, etc.). Contaminants from human societies are often solid, liquid or gaseous by-products and wastes produced when our resources are extracted, processed, made into products and then used. Some forms of pollution also take the form of unwanted energy emissions such as excessive heat, noise or radiation.

Pollution that comes from a single, identifiable source such as a smokestack of a power plant, the drainpipe of a packing plant, a leakage from an underground storage tank, the chimney of a house or the exhaust pipe of a car are termed **point source pollutants**. This type of pollution comes from one place in a concentrated manner and is easy to identify. Many other pollutants enter the air, water or soil from dispersed and often hard to identify locations and are termed **nonpoint source pollution**.

Examples of Nonpoint Source Pollution

Acid Deposition: Acid deposition is rain, snow and dry-deposited particles from the atmosphere that human activities have made more acidic than would naturally occur. Natural rain is actually slightly acidic (pH of 5.6) because of carbon dioxide, a common gas in the atmosphere which combines with water droplets to form carbonic acid. Other natural sources such as volcanoes, wetlands, the oceans and airborne dust can also influence the acidity of rainfall either up or down. Human-made acidity in the atmosphere principally comes from the burning of fossil fuels as well as other industrial and automobile emissions. Acid deposition is thought to contribute to the removal of nutrients from the soil and the addition of toxic metals to the water from the soils. Acid deposition is also credited with negatively affecting tree growth and reproductive failure or death in aquatic animals.

Animal Wastes: Disease-causing microorganisms known as pathogens are present in human and animal wastes or fecal matter. Diseases that can result from exposure to pathogens include dysentery, hepatitis, food poisoning and parasitic infections. Some bacterial contamination can be caused by the untreated wastes of humans, pets, livestock and concentrated populations of wildlife.

Excessive Nutrients: Two naturally occurring nutrients, nitrogen and phosphorus, are required by most plants to survive and reproduce. Excessive amounts of these nutrients disrupt the balance of plant and animal life in an ecosystem. An oversupply of nitrogen in water can enter from the atmosphere or be caused by leaking septic systems as well as fertilizers and manure from farms and lawns that are carried into the waterways by runoff. Excessive amounts of phosphorus can also be caused by contributions for the atmosphere as well as fertilizers, industrial wastes, domestic sewage, agricultural wastes, automobiles and some laundry detergents as well as grass clippings and leaves.

Household Hazardous Waste: The toxic or poisonous substances in a home such as oven cleaners, gasoline, nail polish remover and paints enter waterways when improperly disposed of onto the ground or down a drain. When dumped into a sink, these chemicals can harm the needed bacteria of a septic system or wastewater treatment plant.

Litter: Litter takes many different forms from roadside trash to overflowing dumpsters and unswept parking lots to grass clippings and leaves piled along curbs or dumped into ditches. Not only does litter collect in areas and cause local problems but it also can travel far from its original location through waterways creating hazards to wildlife and possible contamination of water sources.

Motor Oil: Improper disposal or leakage of motor oil is a grave environmental concern. The toxic substances in motor oil, including lead and other chemical additives, seriously pollute ground and surface waters, killing algae and other aquatic plants, smothering aquatic animals, contaminating edible fish and drinking water supplies.

Pesticides: Pesticides, which include insecticides, herbicides and fungicides, contain various substances that can negatively impact human health as well as the environment. These types of chemicals are used agriculturally and domestically and it is their improper usage which leads to pesticide-laden runoff and groundwater sources.

Road Salts: Road salts are currently used to de-ice surfaces of highways, parking lots and other paved areas. However, the runoff of saline water from these surfaces and the improper storage of road salts may cause contamination of groundwater supplies, retard the dynamics of seasonal water mixing in waterbodies, and also change the salinity of water needed to support aquatic plant and animal communities.

Sediment: Sediment such as tiny soil and rock particles are carried by rain and snowmelt into waterways increasing turbidity, reducing light penetration, carrying chemical pollutants and accumulating along channels and bottom surfaces. Sedimentation can occur as a result of soil erosion from poor agricultural practices as well as construction and other types of land disturbances in rural, urban and suburban areas.

Toxic Metals: These include metals such as mercury, nickel, chromium, zinc and lead. They are considered to be toxic to living organisms because of their ability to cause serious health effects if concentrated in the body through accumulation. These metals often originate from cars, industrial wastes and the misuse of pesticides. All of these sources are often transported by water runoff.

Who is responsible?

As stated by US Congressman James L. Oberstar in the EPA Journal, May 1986, "Nonpoint source controls are everyone's responsibility - federal, state, and local governments, local groups and organizations, as well as individual farmers, foresters, mining and construction companies." To take that statement a step further, nonpoint source pollution can be seen as the responsibility of everyone also. Each example of this type of pollution touches a part of our everyday lives. Perhaps in this way we may find a truth in Melodie Beattie's words "We cannot change others, but when we change ourselves, we may end up changing the world." By reducing our individual contributions to nonpoint source pollution and educating others about the environmental effects of our actions, we will be able to work toward preventing further damage to our water supplies and aquatic ecosystems by nonpoint source pollution.

One In A Billion

Grades: middle and upper
Objective: to illustrate the magnitude of the concentration - parts per billion
Subjects: Life Sciences, Chemistry, Math, Social Studies

Materials: 3 one-liter beakers or plastic bottles, food coloring, graduated eye dropper, graduated beaker or cylinder for measurement or volumes, water, paper and pencil, calculator (optional)

Information:

One part per billion (ppb) of almost anything seems like a minuscule amount that often seems too small to even comprehend. If you look at one part per billion share of a square mile piece of land, it would only amount to 2 square-inches of soil.

On the other hand, one part per billion can seem like a lot if the number is measuring dangerous substances like toxins that do not need to be present in large amounts to do significant damage. For example, the volume of water in the Chesapeake Bay and its estuarine tributaries equals approximately 74 million acre-feet. If the following contaminants were present in that volume of water at one part per billion level, they would represent enough raw material to:

- cast 25,000,000 lead bullets
- plate 1.25 million car bumpers with chromium
- fill 100,000,000 medical thermometers with mercury
- fill 125,000,000 aerosol cans of bug killer with insecticides

Of course, in reality, concentrations of these substances vary from place to place in the Bay. So called "hot spots" often have concentrations greater than 1 ppb, but in most areas of the Bay concentrations are less than that. Further monitoring is needed to determine exactly what loads of toxins are present. (The Chesapeake White Paper, August 1988)

This series of experiments and mathematical problems will demonstrate to your students the volume involved in these minute measurements.

Procedures:

1. After discussing scientific studies that view water contamination by toxins, note the measurements of one part per billion (ppb) and one part per million (ppm). Begin these experiments by explaining to your students that they will be doing a serial dilution to get to know these minute values.

2. Start with each of the three bottles containing 999 milliliters of clean water.

3. To Bottle #1, add 1 ml of food coloring (approximately 20 drops) to represent the pollutant. Note and record the color of the bottle's water. Ask your students to calculate the volume of this bottle: 999 mls of clean water + 1 ml of pollutant which equals 1,000 mls of contaminated water. Next, have them calculate and record the dilution of this bottle: 1 ml of pollutant per 1,000 mls of water = 1 part pollutant per thousand parts water.

4. To Bottle #2, add 20 drops from Bottle #1 and mix well. Note and record the color change in the bottle's water. Ask your students to calculate the volume of this bottle which should also be 1,000 mls. Next, have them calculate and record the dilution of this concentration: 0.001 mls of pollutant per 1,000 mls of water equals 1 part pollutant per million parts water.

5. To Bottle #3, add 20 drops from Bottle #2 and mix well. Note and record the color change in the bottle's water. Ask your students to calculate the volume of this bottle which should also be 1,000 milliliters. Next, have them calculate and record the dilution of this concentration: 0.000001 mls of pollutant per 1,000 mls of water equals 1 part pollutant per billion parts water.

Variations:

- Mathematics can take on a fun dimension when the students use it to calculate just how far apart one million and one billion really are. Some useful figures in setting up a math lesson around these numbers are:

  A stack of U.S. paper currency one inch high will contain 233 bills. If you had a million dollars in thousand dollar bills, the stack would be 4.29 inches tall. If you had a billion dollars in thousand dollar bills, the stack would be 357 feet tall or almost the length of a football field. (Access, May/June 1994)

  If you were traveling on the Concorde, you would be able to circle the globe in only 18.5 hours (at a cruising speed of 1,340 miles per hour). At that speed, it would take the Concorde 746 hours or 31 days to travel one million miles. At that speed, it would take the Concorde 31,094 days or 85 years to travel one billion miles. (Access, M/J 1994)

  1 inch in 16 miles = 1 part per million

  1 drop of water in an Olympic-sized swimming pool = 1 part per billion

  1 drop of water in a railroad tank-car = 1 part per billion

  Assuming that a person could count non-stop at an average of 2 seconds per number, it would take someone about 23 days to count to one million.

- Another math lesson in understanding what "parts per" means is to have your students calculate what part of their surroundings they constitute. Start with the statements:
  There are _____ people in your family. There is only one you.
    This means that you are one part per _____ in your family.
  There are _____ students in your class. There is only one you.
    This means that you are one part per _____ in this class.
  Continue on using increasingly broader and larger groups.

- For a two week period, try to collect one million of an item (i.e. buttons, soda can tabs, pennies). Keep the items small and also keep in mind creative ways of disposing of the items at the end of the time period (i.e. fund raiser, recycling, garden or art projects).

Watershed Discussion Questions:

- How would you know if the pollutant were in surface or groundwater reservoirs?
- Why is it important to know about these small amounts of chemicals?
- Is the solution to this pollution dilution?

Sources: Activities are adapted from *New Adventure* in My World, My Water and Me and *Demonstration: Serial Dilution - Parts Per Billion* in Hidden Treasure

Nonpoint Source Pollution On Stage

Grades: all grades
Objective: to investigate the causes of nonpoint source pollution, their effects on the environment and ways that this pollution may be prevented
Subjects: Life Sciences, Chemistry, Social Studies, Drama, Economics

Materials: A copy of *Nonpoint Source Polluters* stories

Information:

"... we use too many pesticides in this country - a billion pounds a year. That's too many. It's put on the crops. It runs off into our rivers and lakes that become our drinking water."
- *EPA Administrator, Carol Browner*

Nonpoint sources of pollution (NPS) are defined as sources dispersed over large amounts of land that also discharge pollutants into the environment over a large area. Waters from precipitation fall to the ground and runoff over soils following natural and human-made water courses. Pollution mixing with the water as it runs off and seeps from land areas is a direct result of how we use the land. Wastes from animals, litter, oils and greases, chemicals from our products and soils from construction sites, plowed fields and stream banks all wash from the land and enter our streams, lakes, estuaries and groundwater.

The following activity will help students become familiar with some examples of nonpoint source pollution in their everyday lives. Students are generally surprised to find that they contribute to this environmental concern. Therefore, it is important to include in this lesson the fact that through some minor changes in their lifestyle decisions, they can help to prevent many causes of this type of pollution.

Procedures:

1. Begin by dividing the class into groups of three or four. Explain to the class that you will be giving each group a different example of nonpoint source pollution written on a piece of paper. Announce to the students that each group will need to act out their pollution story for the rest of the class. When performing, the students are not allowed to speak but they may make noises to simulate their actions. Give the groups a private space in the room and time to discuss and rehearse their performances.

2. When everyone is ready, have the groups perform their interpretations. After each performance, have the class determine the following on each subject: Describe the scene and determine the example of NPS pollution being played-out. Discuss who and what might be affected by this type of pollution. List ways in which this example of NPS pollution can be prevented.

Watershed Discussion Questions:

- What forms of NPS pollution can be avoided?
- What sources of NPS pollution are present in your watershed?
- How are NPS pollutants like the sand in an hour glass?

Source: Adapted from *Nonpoint Source Pollution - Live!* in Beneath the Shell

Nonpoint Source Polluters

Examples of NPS pollution for use in the activities

Nonpoint Source Pollution On Stage and *Washing Away*

#1 "Bugs, bugs go away!"
Mr. Jones has two large trees near his porch which attract wasps, mosquitoes and caterpillars. He sprayed the trees with a chemical that would kill the insects. Shortly after he sprayed the pesticide, a storm started washing the chemical into the soil and down the driveway. From there it washed into the nearby storm drain along with the rest of the rainwater. (For the *Washing Away* Activity, mix a few drops of green food coloring with water in a spray bottle. Spray the green water into the aquarium.)

#2 "We have a problem with that stream."
A small stream winds through a popular golf course. During heavy rains, the stream is filled with fast, flowing water. The sides of the stream are crumbling and the roots of the bordering trees are showing. The land near the stream banks is slowly collapsing. After each rain, fertilizers, soil and small rocks are swept away with the water. (For the *Washing Away* Activity, add soil, sand and pebbles to the aquarium.)

#3 "Where should I put this old motor oil?"
Jocinda is proud to help her dad change the oil in the family station wagon. She clumsily carries the huge pan of black, thick oil to the storm drain where she dumps it. "It's gone!" she proudly exclaims. Soon the oil mixes with the water of a nearby stream. The oil that she spilled on the ground begins to seep into the soil and mix with the ground water. (For the *Washing Away* Activity, add vegetable oil to represent the motor oil from the vehicle.)

#4 "The raccoons are littering again!"
One snowy winter night the Palmer family heard raccoons turning over their garbage cans out by the curb, but it was too cold to go outside and chase them away. The next morning, no one had time to clean up the garbage strewn all over the street. When the snow melted, some of the trash floated with the water into the storm drain. (For the *Washing Away* Activity, add samples of food and paper waste to the aquarium.)

#5 The Lawn Clipping Caper
Carlos helps his grandparents by cutting the lawn. When his grass catcher is full, he dumps his grass clippings into a nearby storm drain. There, the clippings turn yellow and begin to smell until the next storm carries them away. (For the *Washing Away* Activity, add grass clippings or shredded paper to the aquarium.)

#6 "Good Jasper!"
Kyoko enjoys walking the family dog, Jasper. When Jasper needs to go to the bathroom, Kyoko is careful to make Jasper go along the curb so that Jasper is not messing the neighbor's lawns. She doesn't worry though, eventually the mess will go down into the storm drain. (For the *Washing Away* Activity, add two twigs to the aquarium.)

#7 "Don't mess up the car!"
The Harper family likes to stop at fast-food restaurants on the way to the beach. In order to keep the car clean, they throw their bags of trash out the car window into the streets. (For the *Washing Away* Activity, add trash to the aquarium.)

FROST VALLEY YMCA

Washing Away

Grades: elementary and middle
Objective: to demonstrate the causes and effects of nonpoint source pollution
Subjects: Earth and Life Sciences, Chemistry, Social Studies, Health

Materials: A copy of *Nonpoint Source Polluters* stories, an aquarium, water, a cardboard box, food coloring, a spray bottle, soil, sand, gravel, vegetable oil, cafeteria waste and trash, grass clippings or shredded paper and two small sticks

Information:

"Surely it is time to ask whether we really want to continue attempts to manage persistent toxic substances after they have been produced or used, or whether we want to begin to prevent their existence in the ecosystem in the first place." - *International Joint Commission Sixth Biennial Report*

Where do things go when they float down into a storm drain? Should they really be out of our minds once they are out of our sight? It is true that each individual storm sewer inlet contributes just a small amount of pollutants at one time. Yet, considering the input from the thousands of storm drains there are in a system, the pollution concentrations often exceed the limits established for industries and wastewater treatment plants. It is important to note that these contaminated waters generally run directly into participating waterways without any form of filtration or disinfection. As students study the effects of storm drain runoff on the environment, it is often difficult for them to picture the actual damage being done by the seemingly small acts of nonpoint source pollution.

This activity is designed to illustrate to the students what an average street storm drain can collect during a rainfall and how their actions combined with others can lead to dramatic changes in the quality of the waters of aquatic environments.

Procedures:

1. Introduce this activity with a discussion of storm drain systems and their purposes in an urban area. Talk about where the water goes after it enters a storm drain. Have the students list on the board all of the items that they can think of that might enter a storm drain during a rainfall.

2. Explain to the class that they will be making a storm drain in the classroom and dropping into it things that represent the average nonpoint sources of pollution from your community. Begin by bringing an aquarium into the room and placing it in an accessible area where it is easy to view. Fill it half full with water. Place a box on top of the aquarium with a hole cut into it, representing the storm drain. The water in the aquarium represents the waterway where the stormwater mixes after entering the storm drain. Leave the aquarium's sides uncovered so that the students are able to view its contents.

3. Now that the storm drain has been created, let the rains begin. Using the list of *Nonpoint Source Polluters* as samples of what can enter a storm drain, read the stories of each example of NPS pollution and add the appropriate "pollutant" to the aquarium.

4. After each addition to the drain, discuss the following: How does the action in the story damage the environment? Do you think that the people in the story really wanted to damage the environment? Why did they do what they did? How can this source of pollution be changed or stopped?

5. When the class is finished adding pollutants to the drain, examine the aquarium's contents. Discuss how the water changed since the beginning of the activity and how viewing the accumulation of the pollutants makes them feel?

Extensions and Variations:

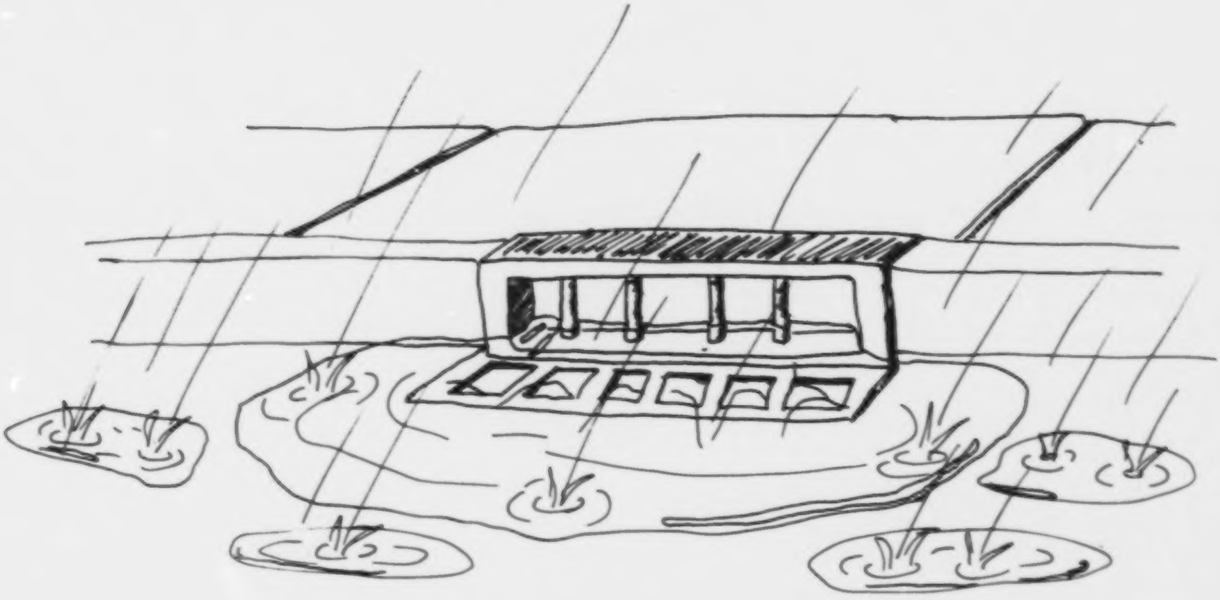
- After doing this activity with the class, encourage each student to invent a method, project or mechanism that would remove such chemicals and objects from stormwater. Try cleaning up the water in the tank. What was easy to remove? What was difficult to remove?

- Have the class create a list of ways to prevent people from contributing to NPS pollution.

Watershed Discussion Questions:

- What types of point and nonpoint source pollution do upstate communities possibly contribute to New York City's water supply system?
- What types of pollution are possibly added to the waters by downstate communities?
- What types of water pollution does nature add within the watershed systems?

Source: Adapted from *Storm Drain Watch* in Beneath the Shell



The Choice Is Yours

Grades: middle and upper
Objective: to exercise decision-making skills in choosing a method of chemical pest control
Subjects: Earth and Life Sciences, Chemistry, Math, Social Studies

Materials: A chalk or white board, sealed containers or labels from chemical pesticides

Information:

"Too often we give children answers to remember rather than problems to solve."
- *Roger Lewin*

By encouraging a class to investigate the information available to use in their own decision-making, students become more equipped to make the choices and conclusions that they will use throughout their lives. In the case of choosing the right pesticide for a particular location, involving the students in the choice of which product is best for the situation has a more lasting effect than memorizing which chemical is good or bad for the environment.

In choosing the appropriate pesticide for a location there are three factors that determine how severe the effects of a pollutant can be. First is its chemical nature or how active and harmful the pollutant is to living organisms. Second, we must consider the concentration or amount per volume present in considering its potential hazardous. And third, we must look at the pollutant's persistence or how long it will stay in the air, water, soil or even our bodies. Some pesticide properties have a more obvious effect on water quality while others are more subtle. When estimating site-specific water quality risks, the effect of the pesticide must be considered in relation to that site's characteristics. The characteristics that we must consider include soil type, slope, depth and surface water. In addition to site characteristics, the following specific pesticide characteristics need to be analyzed when selecting the lowest risk pesticide for a given site and purpose.

Half-Life in Soil: This is the time in days required for pesticides in soils to be degraded so that their concentration decreases by one-half. "Persistence time", as it is often stated in the literature, is the time required for a pesticide to degrade so that it is no longer active.

Soil Sorption Index: The index for soil sorption is measured by the Koc value. The Koc measures the tendency of the pesticide to be strongly attached, by chemical and physical bonds, to soil particles. The higher Koc values (1000) have a stronger attachment to soil and a lesser tendency to move except with sediment movement. The lower Koc values will tend to move with the water and have a potential for deep percolation below the root zone or even being carried distances by runoff water.

Runoff Potential: This indicates the tendency of the pesticide to move with sediment in water runoff. The larger the chemical's rating, the higher its tendency.

Leaching Potential: The ratings of large, medium, small and total use describe the pesticide's potential for leaching or moving with water below the root zone into deep percolation. The larger the chemical's rating, the higher its tendency.

Use Rates: New low-use rated pesticides (sulfonylurea herbicides) are said to be environmentally safer because of their low toxicity and their less concentrated solutions used. They are considered to have a low toxicity rating because they act on an enzyme in plants that is not in other living species. These low-use pesticides are typically used at fractions of ounces per acre rather than pounds per acre like most other herbicides.

It is important to note that if lower risk pesticides options are not available, the user should be advised to consider organic alternatives such as tillage practices or manual weed control and crop rotations in order to reduce the pests.

The following activity will encourage your students to examine a situation in need of chemical pesticides and provide them with the opportunity to practice the decision-making skills involved in choosing which chemical is best suited for a specific location.

Procedures:

1. After a discussion of pesticides and their uses and misuses, give the class a chance to examine some containers and instructions for some of the commonly used pesticides. After time for comparison and contrast of the characteristics of each of the chemicals, have each student sit down facing one partner. In these pairs, the students will have the opportunity to share their opinions and reasoning behind the choices they make regarding these pesticides. For ease in communicating with the pairs, have the students decide which one of them will be designated an apple and which will be an orange.
2. Present the class with the following hypothetical pesticide choices:
   Pesticide A: has a large leaching potential and a low sorption index
   Pesticide B: has a low leaching potential and a high soil sorption index
   Both chemicals target the same pests and are identical in all other characteristics.
3. Next, present the class with the following question: Which pesticide would you select for a field with little erosion positioned over a high water table which contains relatively shallow wells? (answer: Pesticide B with a low leaching potential) After giving the students time to silently consider their decision, explain that there will be a special format for this activity that will allow them to voice their opinion. For the first three minutes of this activity, the apple students will be allowed to talk to their partners about their choice of pesticides. The oranges are encouraged to listen but are not allowed to speak during this time period. After the apples have had their three minutes, give the oranges the same amount of time to give their opinion to their partner, instructing the apples to remain silent. When both partners have had a chance to talk, give the students an additional four minutes to discuss their choices freely with their companion.
4. Next, with that discussion in mind, present the following question for consideration: Which pesticide would you select for a field on moderate sloping land with erosion potential? They should also know that the field is situated in the watershed for New York City and other smaller community drinking water supplies. (answer: Pesticide A with a low runoff potential) Follow the same discussion format as for the initial question.
5. After ample time for discussion both in pairs and with the entire class, take another look at the examples of pesticides you have available. Have the students determine which would be the least water quality risk for either of the selected fields. After concluding this activity, have the students explore the organic and non-chemical management practices used for pest control today.

Watershed Discussion Questions:

- Name some examples of places in your community in which pesticides are used.
- What are some good reasons for using pesticides? (i.e. produce quality and freshness)
- How do we get a balance between the uses and needs for pesticides?

Source: Adapted from *Pesticide Selection Exercise* in A Hidden Treasure

In A Bind

Grades: all grade levels
Objective: to evaluate the harmful effects of litter in respect to wildlife
Subjects: Earth and Life Sciences, Social Studies, Health

Materials: A plastic six-pack holder, a small to medium size rubber band for each student

Information:

Two-thirds of all liter consists of packaging materials.

Not only is litter unsightly, it can be dangerous to wildlife. Birds can starve when stray bits of fishing line wrap around their bills or strangle when plastic six-pack loops slip around their necks. Fish, Sea Turtles and Dolphins are also frequent victims of floating plastic waste mistaken for food.

Large land animals often cut their tongues when foraging among discarded food cans. Glass and metal containers can be lethal traps for smaller animal species, like chipmunks and mice. Broken glass is an obvious hazard for all living animals including people and their pets.

Many animals have died swallowing bottle caps, cigarette butts, candy wrappers, plastic bags and even lollipop sticks that have been carelessly thrown away as litter.

The following activity is an excellent empathy builder for students to experience when considering the harmfulness of the litter they often dispose of quite carelessly.

Procedures:

1. Begin the activity with a discussion and demonstration of how an aquatic bird or mammal might get tangled in a six-pack holder that was carelessly thrown away.
2. Next, pass out a rubber band to each student. Instruct the group to loop their bands over their left thumb and little fingers, stretching the rubber band tight across the back of their knuckles.
3. Have the students imagine that their fingers are a duck's bill tangled in fishing line or a six-pack holder. Their task is to free their fingers using only their feet, much like a trapped animal would have to do.
4. After everyone has attempted to free themselves, facilitate a discussion on the students' reactions to this exercise. Some possible discussion questions would be: How would you feel if you had to struggle all morning? What if you missed lunch? Then dinner?
5. Conclude the activity with a discussion on ways in which we could reduce the occurrence of these hazards (cut all plastic beverage loops before disposing of them).

Watershed Discussion Questions:

- Why do people litter?
- What pieces of litter did you see today that would be considered harmful to wildlife?
- What can we do to reduce the amount of litter in our area?

Source: Adapted from *Evaluating Litter's Harm* in Revise, Recycle and Recover: Realizing Our Resources

Oil Spill Emergency!

Grades: middle and upper

Objective: to simulate an oil disaster exploring the clean-up procedures and the consequences on the wildlife present

Subjects: Earth and Life Sciences, Social Studies, Chemistry, Economics, Health

Materials: One aluminum pan (per small group of students), water, markers, dishwashing soap, vegetable oil, soy sauce, eye dropper, hand lens, feathers, cotton balls, nylon stocking pieces, paper towels and one deep container of water

Information:

"Are humans and our environment in danger from persistent toxic substances now? Are future generations in danger? Based on a review of scientific studies and other recent information, we believe the answer to both questions is yes." - *International Joint Commission Sixth Biennial Report*

Toxic substances in water take on many forms and are derived from a variety of sources. To understand fully the effects of water pollution on the human communities and wildlife ecosystems, let's take a closer look at one particular form of water contamination - oil spillage.

The effects of oil pollution on an ecosystem or water supply are often complex and may be influenced by the time of the year, the type of oil spilled as well as the growth stages of the organisms affected. Oil spills can damage bird feathers, saturate mammal fur, suffocate fish and poison a wide range of life forms that live in and around oil-fouled water. Oil also interferes with the reproductive cycles of many species, a problem with far-reaching implications for an entire ecosystem. In reference to oil entering human drinking water systems either from point or nonpoint sources, a single milliliter of oil is capable of contaminating a vast quantity of water rendering it nonpotable.

When large oil spills occur, there are three common clean-up methods. Chemical surfactants are used in the United States only under strict regulations. Sprayed from low-flying aircrafts, these chemicals act like detergents to dissipate the oil. Although toxic, the chemical dispersants are thought to cause less damage than a spreading oil slick. Chemical treatment is also relatively inexpensive. Mechanical clean-up is another method used in which the oil is contained by booms and absorbent materials like straw, cotton or nylon are used to soak up the pollutant. This method is more expensive and may take longer to implement than the dispersants. One of the latest advances in oil clean-up involves the use of hydrocarbon-consuming bacteria, unfortunately the long term effects of releasing "oil eating microbes" into the natural environment are still not known.

The following activity will give your students the opportunity to try to control an oil spill, enabling them to compare and contrast the effectiveness of the available clean-up methods.

Procedures:

1. Introduce this activity with a discussion of the ways in which oil enters an ecosystem and the ramifications of this form of water contamination on the environment.
2. Divide the students into teams of two, giving each group one complete set of supplies. During the activity, use a mixture of vegetable oil and soy sauce to simulate motor oil.

3. Instruct the teams to examine their feathers with a hand lens, recording any specific characteristics they find. Encourage the students to dip their feathers into an aluminum pan half-filled with clean water and observe the feathers characteristics when wet.
4. Have the teams put five drops of oil in their pan of water. Next, instruct them to dip a dry feather into the oil and water solution for one minute. Once they remove the feather from the water solution, ask them to re-examine this feather and record their findings. How does this feather's reaction to the oil solution differ from the feather dipped into the clean water solution?
5. With the supplies available to them, have the students try to clean their oily feather. Whether they choose to use the water and detergent, cotton, nylon or paper towels, each group should take note of their successes and record their efforts.
6. After the clean-up efforts are finished, facilitate a discussion on the effectiveness of the methods as well as the consequences of the contamination on the feathers and thus aquatic bird species.

Watershed Discussion Questions:

- Why do companies risk oil spills? Are there alternatives?
- In what ways do individuals add oil to a water supply?
- Why is it dangerous for us to use real motor oil for this activity?

Source: Adapted from *Oil Spill!* in Revise, Recycle and Recover: Realizing Our Resources

The Scientific Method

Natural Scientists

Biology is the study of all living forms, as individuals and as interdependent entities. Therefore, a biologist is above all a natural scientist. The sciences of biology cover such a broad range of topics that, in hopes of becoming more accurate with his/her studies, a scientist will often choose to specialize in one particular branch of biology such as:

Botany: the study of plant life
Ecology: the study of the relationships of living things to their environment
Embryology: the study of the early stages of living organisms
Entomology: the study of insects
Ethology: the study of animal behavior
Ornithology: the study of birds
Oology: the branch of ornithology that studies birds' eggs
Physiology: the study of life processes, activities and functions
Protozoology: the study of one-celled animals
Zoology: the study of animal life

An individual that wishes to investigate the composition, structure, properties and reactions of matter especially in regard to atomic and molecular systems will study chemistry. Or if someone has an interest in the origin, history and structure of the earth, he/she would study geology. In all branches of the sciences, knowledge is obtained in fundamentally the same manner - the scientific method.

The Method of Sciences

The Scientific Method is a set of principles which guide a scientist through the formation of a concept from the conduct used for observations and experiments to the validation of a hypothesis and the determination of a scientific theory or law.

A particular natural event is called a phenomenon. In seeking to understand how a phenomenon takes place, a scientist will first use his/her training and background to make an intelligent guess as to what is really happening. This guess is called a hypothesis or "an explanation that accounts for a set of facts that can be tested by further investigation" (*The American Heritage Dictionary*). In order to prove this hypothesis, a scientist may then undertake a series of observations or experiments in which the phenomenon occurs over and over again under carefully controlled conditions. It is not enough to simply amass data. The data or results of the observations and experiments must be reliable. Therefore, a great deal of thought goes into the set-up and execution of controlled experiments including all of the variables involved. Any good scientist must be ready to alter or even abandon his/her most cherished hypothesis when new facts contradict it. When the weight of evidence seems to indicate that the hypothesis is sound, the scientist may then announce his/her findings as a theory. If a theory is subsequently proven to be a non-varying performance in nature, the scientist is said to have discovered a natural law. Theories and laws are then applied to and used as a basis for understanding other phenomenon in nature. Thus the equation for scientific progress is said to be:

Careful observation + Intelligent thought + Persistent search for truth = Scientific Progress

The following activities will guide your students through investigations and observations in the studies of water contamination into topics in experiment terminology, the effects of water chemistry on biological systems and the sources of point and nonpoint pollution.

Finding Phosphorus

Grades: middle and upper

Objective: to measure the amounts of phosphorus found in a variety of water samples and discuss potential problems created by excessive nutrients in an ecosystem

Subjects: Earth and Life Sciences, Chemistry, Social Studies, Health, Economics

Materials: Plastic cups, phosphorus/nitrogen test kits, an eyedropper, water samples

Information:

"A 1991 study of 85 coastal watersheds in the U.S. found that upstream sources accounted for about 70% of the nitrogen and 60% of the phosphorus entering coastal estuaries."
- *Teacher's Guide to World Resources*

It is a well known fact that phosphorus and nitrogen are nutrients necessary for plant growth. Gardeners and other agriculturists use these nutrients in many varieties of fertilizers to promote good healthy garden beds and crops. In a natural environment, phosphorus is the plant nutrient which is usually least abundant in freshwaters and often is the most significant factor limiting plant growth. Therefore, when excessive phosphorus enters a water environment either from atmospheric or human stores, it can trigger the rapid growth of algae and aquatic weeds. This enrichment of lakes, and to a lesser extent streams by plant nutrients, is called eutrophication. As plant growth accelerates, their overabundance immediately affects the wildlife that depend on a balance of species present in order to survive. In addition, most bodies of water become choked with algae and weeds. They then naturally fill over long periods of time. These bodies of water will eventually evolve into bogs or marshes ultimately filling to become solid land. Human activities often increase the amount of nutrients reaching these water bodies and thereby can also speed up this aging process.

The following experiments will help students identify the presence of phosphorus and nitrogen in water samples and to investigate the potential sources of these nutrients.

Procedures:

1. With the students in groups of 3 to 4, have each group collect a water sample from a different location. Some suggested areas for sampling would be: tap water, rain or snow, a puddle, a stream, a pond, a ditch, a gutter after a rain, a rain spout from the roof, water obtained by rinsing soapy hands, water mixed with laundry detergent, liquid plant food.
2. Measure the samples as per the kit directions. Compare the students' findings. Discuss any relationships between the amounts of nutrients in each sample and their sources. Arrange the sources in order from most to least concentrated. Discuss with the class how the nutrients got into the samples and where they are heading next. For more info. on the effects of nutrient loading on aquatic plants, see *Too Much Of A Good Thing*.

Watershed Discussion Questions:

- Is it possible to remove phosphorus from our wastewaters at a treatment plant?
- What other substances do our everyday products add to our watersheds?
- Why is it important to know what substances enter our watershed?

Source: Adapted from *Forever Phosphorus* in My World, My Water and Me

Too Much of a Good Thing

Grades: middle and upper

Objective: to explore the role of algae in an aquatic habitat and the impact of environmental changes on the balance of an ecosystem

Subjects: Earth and Life Sciences, Chemistry, Social Studies

Materials: One clear 10 gallon container, 5 gallons of water, three clear 5 gallon containers, one cup, one eyedropper, tablespoons, paper, pencils, a heat source such as a heat lamp or radiator, calculators (optional)

Information:

Any ecosystem, no matter how simple or complex, needs energy to make it thrive. The organisms that are able to capture energy from the sun and utilize it in order to produce food are termed producers. (For more information on levels of a food chain, see *The Bioaccumulations of Toxins.*) Green plants are generally called primary producers because they are autotrophs, or capable of manufacturing organic nutrients from inorganic substances. Algae, other green plants and some autrophic bacteria fill the primary niche of producers in a pond or stream ecosystem and are thus the base of most freshwater food chains. The process by which green plants produce food from sunlight is called photosynthesis. The formula for photosynthesis is:

$$12H_2O + 6CO_2 + \text{chlorophyll (acted on by sunlight)} \rightarrow 6H2O + 6O_2 + (C_6H_{12}0_6)n.$$

Or stated another way:

water + carbon dioxide + chlorophyll (acted on by sunlight)
yields water + oxygen + carbohydrates (starches, sugars, waxes)

Algae are tiny green plants that come in a wide variety of species, though they are generally simple with no roots, leaves, stems or flowers. Some algae are unicellular, occurring as individual cells such as diatoms. Others live in groups or colonies sometimes forming strings called filaments.

Algae are generally sensitive to levels of nitrogen and phosphorus in the water. An abundance of these nutrients along with a moderate increase in temperatures result in algal blooms or the proliferation of algae in a body of water. Though algae growths in drinking water are not know to create sickness in humans, they can have negative effects on the taste and color of the liquid. The rapid increase of algae growth can actually have a drastic effect on an aquatic environment. As the large amounts of algae die, oxygen in the water is used in the process of decomposition by bacteria and fungi. During this time of high levels of respiration, the dissolved oxygen (DO) in the water is consumed and carbon dioxide builds up in the habitat. Those aquatic organisms that can not tolerate low levels of dissolved oxygen (i.e. many fish, Caddisfly larvae, *Planaria*, Water sow bugs, Mayflies) are no longer able to survive under these conditions. The organisms that can tolerate extremely low levels of DO (i.e. protozoans, *Tubifex* worms, Blood worms, Fly larvae) will now be found in that area .

The following experiment will help students become aware of the effects of changes in nutrient loads and temperature on the growth rate of algae. Getting to know the impact of such changes on this primary producer will aid students in understanding the delicate balance present in an aquatic ecosystem.

Procedures:

1. Begin this experiment several weeks in advance by obtaining algae cultures either through scientific suppliers (for names and numbers, see *A Little Link in the Food Chain*) or collecting algae samples with your students from freshwater ponds or lakes.
2. Culture the algae to insure an adequate population for the experiment by performing the following steps four to eight days in advance. Fill four one-gallon jars with equal amounts of nonchlorinated water. (By leaving tap water uncovered for 24 hours, it will become dechlorinated.) Place equal amounts of algae in each of the four jars. One eyedropper of algae should be adequate. Let the algae cultures incubate in the jars for four to eight days allowing them to adjust to the jar environment and ensure that each jar will have approximately equal amounts of algae growth.
3. Introduce the students to the activity by discussing a food pyramid or food chain of an aquatic environment that involves algae as the primary producer. Explain to the class that they will participate in an experiment to examine the effects of overabundance of two factors in a habitat: nutrients and warm temperatures.
4. Have the students set up and label the four observation jars as follows:
   All jars should have equal amounts of nonchlorinated water and algae. Each jar should also be exposed to similar light intensity throughout the experiment. Jar A should contain water and algae only. Jar B should contain water, algae and plant food (add the amount recommended on product's container). Jar C should contain water, algae and have a heat source such as a heat lamp attached to it. Jar D should contain water, algae, plant food and also have a heat source attached to it.
5. Ask the students to predict the growth rates of each of the jars of algae. Have the students observe the jars daily for one to two weeks and record the amount of algae growth after each observation.
6. Each day, have a group of students filter a small sample of the jar contents for the class to view. To filter the cultures, students should stir the culture thoroughly distributing the algae and then take a small amount of the sample and pour it through standard laboratory filter paper or a coffee filter secured in a funnel over a jar. Display the labeled filters for students to observe and compare.
7. After observing and discussing the effects of nutrient loading and temperature changes on algal growth, have the students consider the following situation. A small lake is bordered by an agricultural area on two sides. It is also within 100 yards of a small vegetable and fruit packing company that periodically dumps warm wastewater into the lake. Water runoff from the farm contains animal waste materials and excess fertilizers. The lake's water appears green as the algae covers nearly the entire surface of the water.
   - Describe the factors that have caused this increase in algal growth.
   - What are the possible consequences of this increase in the amount of algae?
   - How might this problem be prevented in the future?

Watershed Discussion Questions:

- How is an algae bloom like a blister?
- What in your daily routine might contribute to an algae bloom somewhere?
- Can you think of another situation in which "too much of a good thing" is negative?

Source: Adapted from *Algae Bloom and Bust* in Water Wisdom

The United States Geological Survey's Water Quality Studies in the Catskills

"The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased and not impaired in value." - *Theodore Roosevelt*

The United States Geological Survey, being America's largest water-science and water-information agency, is currently conducting a wide variety of water quality investigations of the nation's ground and surface water resources. These studies are meant to provide public officials and concerned citizens with the information necessary to formulate and evaluate water management strategies.

USGS Research at Frost Valley

In the early 1980s, the concern over the effects of acidic precipitation on water quality in mountain lakes and streams led the United States Geological Survey to initiate water studies throughout the United States. The research in the Catskill region, specifically Frost Valley, began in 1983 at Biscuit Brook, a small stream on YMCA property that constitutes part of the headwaters of the West Branch of the Neversink River. This Small Watershed Study was initiated at a time when there were few stations nationwide for monitoring the chemistry and discharge of small mountain streams, let alone the chemistry of deposition in mountain environments. In order to evaluate the importance of acidic deposition to the chemistry of Catskill streams, the relationship between stream chemistry, precipitation and stream discharge needed to be monitored over time, especially during changes in discharges caused by storms and snowmelts. The ten year project included observations of continuous stream discharge, weekly stream chemistry as well as sequential chemistry changes during storms and snowmelts over the period of August 1983 to October 1993. In addition, the studies included the installation of snow and soil lysimeters in 1988 which sampled waters from snowmelt and waters that were passing through the different layers of soils.

The information found during this research encouraged the USGS scientists to further develop studies in this region utilizing long-term stream monitoring programs. The objectives of these studies include (1) the determination of temporal trends in stream chemistry and discharge in headwater streams; (2) the determination of the effect of stream acidity on fish and aquatic insects present; (3) the determination of the range of concentration-discharge relations among Catskill region streams and; (4) the determination of the natural processes in the watersheds controlling those relations. Automated samplers are now used in these studies to sample streams and soil water at any time of the day and night when the flow of the stream changes. Results of these studies can be found in Murdoch (1988), Murdoch and Stoddard (1991, 1992) and Stoddard and Murdoch (1992).

Catskill Studies With Global Ramifications

In past studies and observations, nitrogen has been identified as a major component of acid deposition. Because nitrogen is a major nutrient, its movement through watersheds is affected substantially by biological uptake and release. Human disturbances such as logging can cause large losses of nitrate by promoting its leaching from soils (Likens and others, 1970). It has also been found that subsequent early regrowth promotes nitrogen retention in the accumulating plant life (Nodvin and others, 1988).

Results of the eight year stream chemistry monitoring at locations throughout the Catskills, including Frost Valley, indicated that the soils in the region may be nearly saturated by nitrogen. Considering these studies and others, the USGS scientists then concluded that understanding how nitrogen moves through the Catskill watersheds was critical to protecting the quality of the downstream drinking water reservoirs.

Scientists around the world are now watching for the results of the USGS's most current acid deposition study at Frost Valley. Using instrumentation such as soil lysimeters, shallow piezometers (wells), precipitation collectors, soil-moisture sensors, soil-gas collectors, stream gauges and soil bags, the new study now underway by the USGS on the YMCA's property is designed to record changes in the chemistry of the soil, ground and stream water of a tiny watershed during a controlled alteration of the forest cover. Their interpretation of the data will focus on the following objectives:

- to determine how vegetation affects the movement of nitrogen, especially atmospherically deposited nitrate, in an undeveloped small watershed;
- to define the geochemical processes and hydrologic flowpaths that control the chemistry and movement of nitrogen compounds in forested environments and to relate changes in nitrate concentrations to changes in other soil-water constituents such as aluminum and organic carbon;
- to document the effect of logging and regrowth on the chemistry of forest soils and on adjacent headwater streams in an environment with naturally high surface water nitrate concentrations;
- to determine the effects of deer grazing on vegetation regrowth and soil chemistry; and
- to assess the potential contribution of greenhouse gases to the atmosphere from soils under varied land-use conditions.

The Frost Valley YMCA and The USGS - Partners in Environmental Education

With such exciting, state-of-the-art research going on at Frost Valley, the YMCA, in cooperation with the USGS scientists and technicians, is incorporating these dynamic studies into the center's environmental education programs. The Frost Valley YMCA's Acid Deposition class gives visiting students the opportunity to explore this environmental crisis through direct experience utilizing basic chemistry, the study of the pH scale and lessons in ecology. This science class offered to middle and upper school grades combines a variety of hands-on activities which include games, simulations and experience with scientific sampling techniques. With the United States Geological Survey's monitoring stations on-site, students also have the opportunity to visit, observe and discuss these intriguing environmental research methods.

Frost Valley's Watersheds and Wilderness class takes water monitoring a step closer to home for students from Catskill and New York City communities by exploring the many facets of the water destined for their faucets. Activities illustrating issues in water use and conservation, experiments in stream gauging, water quality monitoring and purification techniques all lead to active discussions making this a thought-provoking class. With the mounting environmental concern of water quality and quantity in our region, Frost Valley has initiated a focus on watershed education for their 1995 curriculum development. For more information on the Watershed Education program and other science-related lessons at Frost Valley, contact Frost Valley's Director of Environmental Education.

Source: Research project information provided by Peter S. Murdoch, USGS Hydrologist and Project Chief for Catskill Watershed Studies.

Studying Acid Deposition

Grades: all grade levels
Objective: to investigate the causes and effects of this environmental concern
Subjects: Earth & Life Sciences, Chemistry, Social Studies, Math, Health, Economics, Gov't

> "Acid Deposition - the falling of acids and acid-forming compounds from the atmosphere to the earth's surface. Acid deposition is commonly known as *acid rain*, a term that refers only to wet deposition of droplets of acids and acid-forming compounds."
> - *Miller*, Living In The Environment

The following lessons are a series of observation activities and experiments that will help students investigate the causes, effects and environmental concerns explored in current acid deposition research.

Patrolling Pollution

It is water's ability to bond with a large variety of substances that causes airborne pollution particles to become dissolved in precipitation and be, in a sense, pulled into water supplies. Possible air pollutants that have been found to cause health problems in humans include lead, carbon monoxide, particulates, ozone, nitrogen dioxide and sulfur dioxide. Most air pollution is invisible because it is made up of microscopic particles and gases. However, some air pollution can be easily observed by setting up this simple observation station.

Materials: Sheets of white paper or cardboard, white petroleum jelly, microscope slides, microscopes, tape

Procedures:

1. Have the students begin by taking two pieces of white paper or cardboard and cover one side of them with petroleum jelly. Next, instruct the students to find a location outside on a window ledge in which their papers will be exposed to the open air. Secure the papers in place either on the ledge by trapping them in the closed window or taping them to the window with the jelly side out. (Gratings or bars on windows should not interfere with this experiment.)

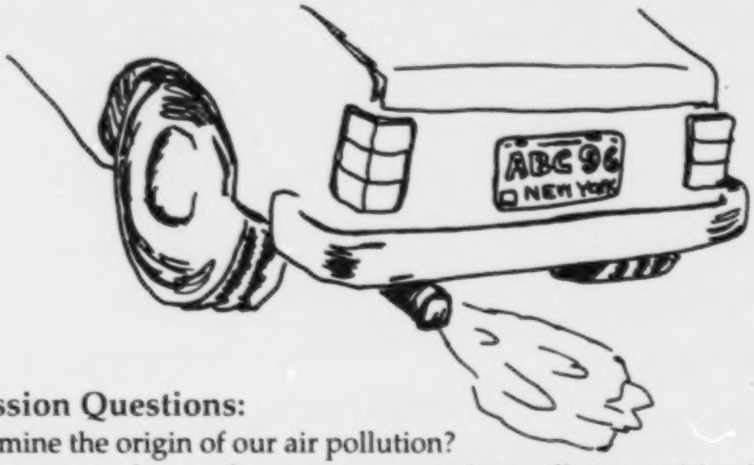
2. After one day, have each student remove one of their papers, leaving the other one for a full week. Compare the two sheets and record the differences in appearance.

3. In order to observe the particles more closely, repeat the procedure using microscope slides instead of paper. This will give students the opportunity to observe the colors, shapes and sizes of the particles under a microscope.

Variations and Follow-up Activities:

- In order to observe the changes in the architecture of your area due to air pollution, find some old pictures of the buildings in your community at your local library or newspaper office. Compare these pictures with the same buildings now. See if they have changed at all over the years.
- While investigating the local causes of your community's air pollution, have the students research and draw a map of your area showing possible sources of pollution.
- While looking into automobiles as one of the sources of air and water pollution, do the following exercise to determine the approximate amount of car-produced nitrogen oxides (NO_x) in your community. You will need these three figures in order to calculate the amount: (1) the average amount of nitrogen oxides produced by each vehicle per mile, (2) the average length of each vehicle trip (In 1982, the EPA estimated that the average vehicle's NO_x production equals 4 grams per mile and the average trip distance to be 5 miles per trip.), and (3) the average daily number of cars on your community's roads (you can do this by counting cars traveling on your road during a period of time and calculating the total then passing in a 24 hour period.). To find the number of cars on your entire community's roads, determine the number of 5-mile segments of road in your community by calling your local road municipality for the amount of miles of roads your community has. Divide this number by five to find the number of 5-mile segments that you have in your area. Next, take the number of cars that you counted in the five-mile segment in front of your school and multiply it by the number of road segments your community has. This will give you the total estimated number of cars using your community's roads in one day. Use the following formula to then find the total amount of NO_x produced in your area in one day:

  4 grams of NO_x x 5 miles (the average trip) x the # of cars traveling in your community



Watershed Discussion Questions:

- How do we determine the origin of our air pollution?
- Do the Catskills have more, less or the same amount of air pollution as New York City?
- Why would someone in New York City be worried about the air pollution in the Catskills which are 100 miles away?
- Why would someone in the Catskills be worried about the air pollution in New York City which is 100 miles away?

Source: Adapted from *What's in the Air?* and *Pollution Patrol* in Acid Rain: A Teacher's Guide, Activities for Grades 4 to 12

Pondering pH

In order to understand acidity, one needs to get to know the pH scale. For it is this group of logarithmically denoted figures that illustrate how acidic or alkaline (basic) a solution is. Simply stated, a solution is more acid when it contains more hydrogen ions (H+), or charged hydrogen atoms. These free charged ions are what gives water its ability to bond with and dissolve just about any substance it comes in contact with given the proper conditions.

The pH scale ranges from 0 to 14 with a value of 0 being extremely acidic, 14 being extremely basic and 7 being neutral. Since the scale progresses logarithmically, a value of 3 is 10 times more acidic than a pH of 4 and 100 times more acidic than a pH of 5. There are several ways of measuring pH. The most precise method is the most expensive by far. For most classroom investigations, however, the inexpensive pHydrion or litmus papers will suffice. (See *The Chemical and Physical Characteristics of an Aquatic Environment*) Ample supplies of these papers can be purchased from biological supply companies. A list of several of these suppliers is available in this guide's activity *A Little Link in the Food Chain*.

When investigating the pH scale, it is interesting to try to alter the acidity of solution by using other solutions' abilities to neutralize it. Neutralization is the act or process by which acids and bases counterbalance each other, producing a neutral solution. For example, if we have 2 mls of an acid like vinegar measuring a pH of 3 and we add 2 mls of a base like household ammonia which measures a pH of 11, the resulting solution will have a pH that falls somewhere between 3 and 11 depending on the concentrations of each of the liquids.

The following activity is designed to help students get to know the pH scale by using commonly found liquids and foods to manipulate the acidity of a solution.

Materials: Litmus paper, a variety of household liquids (i.e. water, juices, vinegar, coffee, milk, ammonia, detergents, pop), a variety of foods (i.e. bread, eggs, tomatoes, grapes, bananas, baking soda and apples), several test tubes or small jars

Procedures:

1. After an introduction to the pH scale and how it works, divide the class into groups of 3 or 4. Provide each group with a small jar or test tube and a couple pieces of pH paper. Next, introduce the students to the household liquids and foods that are available. Give each group a small amount of one of the liquids and have them determine its pH.
2. With all of the products available to them, have each group begin a neutralizing experiment adding any of the substances they choose to their liquid in order to change the current pH to a value of 7. Encourage each group to record their results. Caution the students to take care in adding only tiny amounts of the substances with special care given when using ammonia or other cleaning products. Students should be instructed to never sniff the jars directly or to shake the contents vigorously. A simple swirling action is enough to mix the solutions in the jars and tubes.
3. After the students have had enough time to make a solution with a pH of 7, give each group the opportunity to explain their procedures and findings to the class. Compare the different procedures and results. Conclude the activity with a discussion of acid and alkaline solutions and the pH scale.

Watershed Discussion Questions:

- What parts of the country have the lowest pH measurements for their rain water?
- Can we use this experiment's techniques to change the pH of a lake? Why or why not?
- Does high acidity alone make drinking water non-potable?

Can Nature Cope?

As air pollutants are transported from industries and automobiles, as far as 1,000 kilometers by prevailing winds, forming secondary pollutants such as acids and particles of sulfate and nitrate salts, the communities and ecosystems several states away are affected. The harmful effects of acid rain are far reaching and diverse. Some examples include:

- damages statues, buildings, metals and car finishes
- acidifies environmental waters causing death to many fish and other aquatic species
- contaminates fish in lakes with highly toxic methylmercury - Increased acidity of lakes converts inorganic mercury compounds in the lake bottom sediments into the fat-soluble toxin methylmercury.
- damages foliage and weaken trees, especially conifers
- facilitates the release of aluminum from surrounding bedrock which, in turn, accumulates on the gills of many fish species causing respiratory difficulties and death for these animals
- makes trees more susceptible to stresses such as cold temperatures, diseases, insects, drought and fungi that thrive under acidic conditions
- displaces the potassium, calcium, magnesium and ammonium particles in topsoil with hydrogen ions, thus reducing soil fertility as well as excessive amounts of ammonium in ecosystems can damage tree roots and kill many types of fish
- leads to excessive levels of nitrogen in the soil that overstimulate plant growth and also increase the depletion of other soil nutrients
- contributes to human respiratory diseases such as bronchitis and asthma

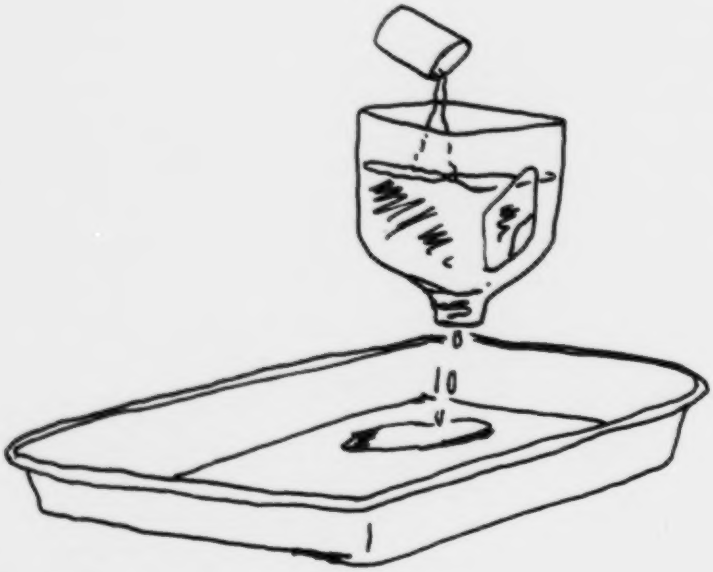
Acid rain is said to have the potential to completely eliminate aquatic life in lakes, streams and ponds. However, the amount of damage this form of pollution is capable of causing depends largely upon an area's soils. As rainwater trickles through soils or over land surfaces, alkaline soils are able to neutralize or buffer the rain's acids. It is interesting to note that the areas in which acid rain is most damaging are often the areas which have soils incapable of buffering the incoming acids. These regions include nearly all of eastern Canada, New England, New York's Catskill and Adirondack Mountains, parts of the Appalachians and much of Minnesota, Michigan and Wisconsin. The Catskills, for instance, commonly have rain water with a pH of 4.28 (Murdoch, USGS/Frost Valley studies, 1991) which the base-poor soils are unable to neutralize. Thus, the effects of acid precipitation are much more evident in this region's ecosystems.

To test a soil's ability to buffer or cope with acid solutions, students can perform the following experiment with soils from your area.

Materials: small plastic garbage bags, soil samples, large plastic gallon milk jugs, filter paper, jars, pH paper, vinegar, baking soda, water

Procedures:

1. Begin by having the class investigate your school grounds for different variety of soils. Using the plastic bags, collect 1 pound samples from a variety of locations.
2. In the classroom, use gallon jugs with their bottoms cut off to serve as large funnels. Have the students place a piece of filter paper at the bottom of each funnel. Next, fill each funnel with a different soil sample.
3. The students then need to mix up an acid solution with a low pH value. 50 mls of vinegar mixed with 150 mls of water will generally give you a solution with a pH of 4.0 depending on the acidity of your water.
4. The experiment begins when the students pour equal amounts of the acidic water through the funnels into catching containers. Compare the resulting pH values for each of the leachates. Determine which soil has the best buffering capacity.



Variations:

- To amplify the alkalinity and thus the buffering capacity of one of the soil samples, add a tablespoon of baking soda to the soil mixture. Record and compare the results with the other samples.
- To illustrate the effects of the acid solution on soils and metals, set a glass of the acidic water aside for a week with a penny or marble chip inside. For comparison, leave a penny or marble chip outside of the solution for the same length of time. Note the changes in the metal or mineral examples.

Watershed Discussion Questions:

- Why would people in New York City be concerned about the Catskill soils' buffering capacities?
- What are some other ways of testing to see if acid rain is affecting surfaces in your area?
- How do we decrease the amounts of acid deposition in our area?

Source: Adapted from *Can the Soil Cope?* in Acid Rain: A Teacher's Guide, Activities for Grades 4 to 12

Acid Rain Tag

Grades: elementary and middle school
Objective: to illustrate the effects of acidification of aquatic habitats on fish species
Subjects: Earth and Life Sciences, Chemistry, Health, Social Studies

Materials: A large playing area suitable for a tag game, four cones or boundary markers, name tags (index cards with string or safety pins) and a marker

Information:

> "We are in somewhat the same position in regard to polluted air as the fish are to polluted water." - *Allan V. Kneese*

Is acid rain toxic to fish? This is the question that the United States Geological Survey's researchers set out to answer at Frost Valley's Biscuit Brook. Many researchers have reported that increases in NO_3^- concentrations at high flows in the streams are often accompanied by increases in aluminum concentrations. (Schofield et al., 1985; Driscoll et al., 1987; Brown, 1988; Murdoch, 1991; Stoddard and Murdoch, 1991) This is thought to be partly due to the mobilization of aluminum at low pH values of the waters which occur during acidic episodes like snowmelts or periodic storms. When the USGS/Frost Valley team researched the aluminum in Biscuit Brook during the snowmelt periods of 1989 and 1990, the data indicated that as much as 60% of the aluminum was in the inorganic monomeric form during peak discharges. (Murdoch, 1992) It is this particular form of aluminum that scientists consider to be most toxic to fish species. (Driscoll et al., 1980)

The following tag game will help students recognize the hazards of acidifying aquatic environments and the benefits to buffering agents in the soils that protect waters from excessive acid shocks.

Procedures:

1. Before introducing this game, prepare the following name tags out of the supplies you have available: 3 Fish; 3 NO_x; 5 SO_2; 2 Buffer (OH^-); and 8 Freshwater (increase the amounts of individuals equally to match the amount of students participating).
2. After the students have a basic understanding on how acidic conditions in waters mobilize minerals in soils,prepare the following tag game. Begin by setting up a large playing area that is free from hazards to running students. Mark the boundaries with cones.
3. Explain to the class that this tag game loosely illustrates the effects of acid rain on fish populations in susceptible aquatic environments. Start by assigning the roles to the students by handing out the name tags. (Do not hand out the buffer tags during this first round of the game.) Instruct the fish and water individuals to roam freely in the pond or play area. These characters may not leave the pond area for obvious reasons.
4. Next, introduce the pollutant characters (SO_2 and NO_x) to the group as acid deposition. These acid-forming particles will have the mission in this activity of binding with the freshwater molecules in the pond area. When the game begins, the pollutant individuals must run and catch a water student by tagging them. At that point the water and pollutant students begin to work as a team portraying an acid (sulfuric or nitric acids). While holding hands, these partners then have the task of running after the fish in the pond.

5. When a fish is exposed to acidic waters in a natural ecosystem, it is affected by the high acidity and often becomes ill and even perishes if the concentrations are high enough or if the acidity releases toxic levels of metals into the water environment. If the acidic partners in the game tag one of the fish, that fish should sit or kneel down on the ground signifying that he/she is ill. A fish affected by acidic waters in a natural environment has a chance of survival if it is able to find fresh pH-suitable waters. So, if an individual fresh-water student free of pollutants is able to tag the sick fish, that fish can then swim freely about the pond once again. Once this happens to a fish three times, the fish is then too sick to survive the fourth acid shock and should step out of the game to "fish heaven" to the side of the playing area.

6. Continue this version of the game until most or all of the fish are ill or gone. Next, start a new game with the addition of the buffer characters. As with buffers in a natural environment, these individuals are able to break-up the acid pairs by coming in contact with them. If, during the course of the game, a buffer tags an acid pair pursuing a fish, the pair must then break apart and the free water is then encouraged to once again avoid the pollutant. The free pollutant should then catch a new water molecule in order to form another acid compound.

7. After continuing this version of the game for some time, discuss the differences in the various environments and other species affected by high acidity in aquatic ecosystems (See *The Chemical and Physical Characteristics of an Aquatic Environment*).

8. Conclude the activity by examining a map of the United States and researching the locations of regions with high amounts of acid precipitation and low buffering capacities.

Watershed Discussion Questions:

- How are buffers able to help fish populations?
- What do you suppose happens to the fish in the Catskill Mountain streams where the soils have very little buffering capacity and the rain is quite acidic?
- Why should people in New York City as well as the Catskill communities be concerned with the acidity of waters in the Catskills?

The Bioaccumulation of Toxins

"Pesticides are among the few toxic materials deliberately added to the environment."
- *Dr. Marion Moses*, Pesticide Education Center

The trophic levels of a food chain

In a functioning natural ecosystem, there is essentially nothing wasted. All organisms, dead or alive, are potential sources of food for other organisms. The sequence of who eats or decomposes whom is called a food chain. The order of the links in these chains determine how energy moves from one organism to another. Ecologists assign every organism in an ecosystem a feeding level or trophic level (from the Greek *trophos*, "nourishment"), depending upon what it eats or uses to produce its food. **Producers**, all green plants and some autotrophic bacteria, are organisms that are able to manufacture organic nutrients from inorganic substances. In the case of green plants, this is done through photosynthesis. (For more information on photosynthesis, see *Too Much Of A Good Thing*.) Producers belong to the first trophic level. The next levels of organisms that get their energy from eating plants and animals are termed **consumers**. As opposed to autotrophs like the photosynthesizing green plants, these organisms are heterotrophs, getting their energy from living or dead organic matter. Depending on its position in a food chain, heterotrophs are termed primary consumers if they eat producers directly, secondary consumers if they eat those who feed on primary consumers, and so on through the levels. The animals and plants that feed on dead organisms are termed **decomposers**. Food chains rarely have more than four trophic levels or energy transfers due to the energy lost at each level for tissue growth, heat production, respiration and work for survival. Actual ecosystems are more complex than a simple food chain. Therefore, the organisms often form a dynamic network of feeding relationships called a food web or web of life.

Bioaccumulation of toxins in living organisms

Once we understand the dynamics of the energy and nutrient transfer of a food chain, we can apply those principles to the cumulative effects of toxins on the wildlife species of an aquatic environment. The case study of the polychlorinated biphenyls (PCBs) in pesticides once used in the United States is a good example of this. PCBs are a group of 209 different toxic, oily, synthetic chlorinated hydrocarbon compounds that are insoluble in water, soluble in fats and resistant to biological and chemical degradation. It is these properties that allow the chemicals to bioaccumulate or remain and accumulate in the tissues and organs of living organisms. Biological amplification is the increase of these chemicals in organisms at successively higher trophic levels of a food chain or web. The United States and Canada banned the use of PCBs in 1976. Yet, the accumulation of these chemicals is still found in our aquatic environments where the millions of metric tons once released, ended up in bottom sediments. The following figures were observed in a recent study of PCBs found in the Great Lakes.

In the water	0.000002 ppm
In the phytoplankton	0.0025 ppm
In the zooplankton	0.123 ppm
In the Rainbow Smelt	1.04 ppm
In the Lake Trout	4.83 ppm
In the Herring Gulls and their eggs	124 ppm

The long-term health effects of people exposed to PCBs is unknown. However, in lab animals and wildlife, high doses of PCBs have produced serious biological damage.

The Great Debate

Grades: middle and upper

Objective: to weigh the social, environmental and economic factors involved in solving the acid rain problem and make value judgments regarding the need for industrial controls

Subjects: Earth and Life Sciences, Chemistry, Health, Economics, Social Studies, Gov't

Materials: The Great Debate Character Roles copied and separated for student use

Information:

"You must do the thing you think you cannot do." - *Eleanor Roosevelt*

Is acid rain really the problem for our lakes and streams? Do we have enough information on the subject to warrant the financial costs involved in implementing changes? Acid rain has proven to be quite a controversial issue. Given the assortment of opinions and the cost of initiating solutions, populations are often divided on attitudes regarding this complex environmental concern.

This role play activity is a lesson designed to help students sort out the facts and formulate their own opinions on the issue. During the debate, they will research both the pros and cons of controlling acid rain and determine the trade-offs of implementing immediate controls vs. conducting further research on the problem. The discussion will focus on the question: Should we act now to implement costly air pollution control measures or should we wait until further research possibly confirms that acid rain and its effects are indeed the cause of acidified conditions in our lakes and streams?

Procedures:

1. In order to introduce the class to both sides of the issue, copy the following articles for them to review:

In favor of immediate control:	"Troubled Skies, Troubled Waters", John Luoma, Audubon, November 1980
In favor of continued research:	"Maybe Acid Rain Isn't the Villian", William M. Brown, Fortune, May 28, 1984

2. To conduct the class debate as a simulation where students assume the point of view and roles of various interest groups, distribute a copy of each character's information to a number of the students in the class. The roles include a variety of perspectives including a forest ranger, an architect, a meteorologist, a mine worker, a resort owner, a power plant worker and a wildlife biologist. The remaining students in the class will act as an international commission representing both Canada and the United States.

3. When the students are familiar with their roles and have their statements formulated, the debate can begin. The commission will hear a maximum of 10 minutes of testimony from each citizen. They then will develop a strategy to deal with the acid rain problem and present it to the class. Some questions the students should consider as they debate the issue include the following:

- What proof exists to support the claim that air pollutants from industry and autos are the cause of acid rain?
- How can we be certain that acid rain is having a negative impact on aquatic life, forests and human health?
- Should the United States take responsibility for reducing the acid precipitation from its industries which affect Canadian lakes? Should Canada take responsibility for their industries which affect U.S. soils?
- What are the responsibilities of private industry to citizens and to foreign governments?
- Are students and their families willing to pay more for utilities if a program to reduce SO_2 is implemented?

4. At the conclusion of the class debate, ask the students to take a stand on the issue. Write the phases "More Research" and "Action Now" on opposite ends of the black board. Ask the students to stand next to the slogan that most closely aligns with their personal point of view. Then, allow each student the opportunity to clarify why they have taken that particular stand and ask them to summarize their rationale for the class.

The Great Debate Character Roles

Dorothy/Don Chen, age 28, Geologist for the United States Geological Survey

From experience, you understand that unbuffered soils are sensitive to acid rain and that soil acidification can have far-reaching consequences. From studies the USGS has done in the Catskills, you know that leaching of metals such as aluminum and iron can harm plants and some animals. Also, it is possible that plant nutrients may be lost from susceptible soils. You therefore feel that while additional research under field conditions is clearly necessary, studies already indicate that acid rain threatens both aquatic and terrestrial systems.

Megan/Bob Robertson, age 31, Consulting Meteorologist

As a member of a Canadian-U.S. research group, you have determined that the levels of transboundry pollution depends on prevailing winds and weather patterns. The net flow of the sulfur is from south to north across the U.S.-Canadian border. On the average, three to four times as much sulfur crosses into Canada as moves into the United States. (Although the flow of sulfur from U.S. sources to Canadian air space is close to the total Canadian emissions in volume, 5.5 million tons.) You feel strongly that the commission should consider this data in making its recommendations.

Anny/Tim Burns, age 25, Chemist for New York Hydro Electrical Power Company

NY Hydro is the second largest source of SO_2 within New York State and the largest industrial source of NO_x. Hydro's coal-fired stations produce about 20% of the total emissions of these two pollutants for the region. Hydro is active in controlling SO_2 emissions by using only washed coal which reduces sulfur levels by 15-20%. Hydro is also installing low NO_x burners and SO_2 scrubbers to combat acid rain. You would urge the commission to require similar standards for emissions in the Midwest States since NYS's actions alone are not effective because polluted air masses enter your area from industrial states to the west.

Gloria/Daryl Knauss,
age 62, Wildlife Officer, New York State Department of Environmental Conservation
The NYSDEC's observations have found that the Catskill Mountains as well as other regions in New York State are susceptible to acid rain. You are familiar with studies showing that in addition to the threat to fish, amphibians including salamanders and frogs, are drastically affected by acid rain. Because the salamander plays an essential role in the food chain, its disappearance would negatively affect the fish, waterfowl and mammals that eat the salamanders. Therefore, you believe that acid rain threatens wildlife and something should be done about it immediately.

Ruth/Henry Hirschauer, age 55, Owner of Angler's Lodge of the Catskill Mountains
Your lodge caters to fishing enthusiasts drawn to the Catskills for their superb fly-fishing streams. The game fish that your patrons seek are the bass and trout that comprise a major portion of the fish populations in the Catskills' acid rain susceptible waters. If these streams become more acidic, fish populations will probably decline and in turn so would the amount of customers for you and other local resorts and outfitter operations. Further acidification of these waters could cut down on the volume of your industry and cost millions of dollars annually plus result in hundreds of people losing their jobs. You will urge the commission to take immediate steps toward eliminating acid rain.

Cindy/Joe Cholewa, age 51, Farmer from Grahamsville, New York
You live in an area that is reportedly threatened by U.S. produced acid rain. Although you've heard that acid rain can damage crops such as spinach, lettuce, bush beans and radishes, and can reduce yields of some crops such as beets, carrots, radishes and broccoli, other crops have had higher yields thanks to the fertilizing effects of acid rain. In your case, corn yields have not declined, but occasionally have increased. You feel the commission should recognize that acid precipitation can sometimes be beneficial.

Christine/Chris Gajewicz, age 47, Professor of Architecture at MIT
As a professor of architecture, you feel strongly that something should be done to curtail acid rain if for no other reason than to spare some of the great buildings of the world from slow destruction by acid deposition. In Athens, marble sculptures dating from the fifth century B.C. are turning into soft gypsum. The cause is air pollution, in particular acid-producing pollutants. U.S. landmarks like the Statue of Liberty, the Lincoln Memorial and the Washington Monument are being harmed by acid washings. The President's Council on Environmental Quality estimated in 1979 that the annual cost of architectural damage alone in the United States was nearly $2 billion.

Grace/Brian McKenna, age 33, Environmental Engineer for The New York Mining Company
Your company would like the commission to consider recommending action to return acidified lakes to their normal pH by liming rather than costly pollution control laws that would affect your companies large mining and smelting operations. In liming, a neutralizing agent, such as limestone, is added to a body of water. According to one estimate, liming 468 of the most acidic lakes in the Adirondacks to a pH of 6 would cost about $4 million per year. The additional cost of scrubbers to 50 of the oldest coal burning plants east of the Mississippi is estimated to cost between $7 billion and $14 billion for capital costs and between $1 and $3.6 billion for annual operating costs. The benefits of liming appear within 1 year; scrubbers take 3 to 5 years to build.

Karen/Mike Godfrey, age 29, Representative of the U.S. Environmental Protection Agency
The current EPA position is that some proposed methods of halting acid rain might foster worse problems. In addition, the agency contends that much of the acid rain is caused locally, contrary to the theory that acid rain in the northeastern United States and Canada is traceable to coal-powered plants in the Midwest. The EPA believes acid rain requires additional scientific study before corrective measures are adopted. Some EPA researchers are even studying how much acid rain is produced naturally.

Maria/Gabriel Mendez, age 44, Union Representative of U.S. Coal Miners
If legislation is introduced in Congress to mandate reductions in emissions, coal industry officials have testified that thousands of mining jobs would be lost in the Appalachian and Midwest coal regions to pay for the costly alterations. Although you cannot vouch for the accuracy of these figures, you would like the commission to be aware of the effects this type of legislation would have on regional economies. You will ask the commission to weigh the costs and benefits carefully. The wrong legislation could destroy the already depressed economies of these regions.

Margaret/Kenneth Ritzski, age 76, Sierra Club Lobbyist
You believe that the commission must take immediate action against SO_2 and NO_x-producing industries. After all, research has shown that these industries are responsible for acid deposition. Waiting for 5 or 10 years for a government investigation may cost the environment dearly. In response to advocates of such remedies as liming, you will point out that liming requires 9 kg per surface hectare per year, which means several tons even for small lakes. Although liming may return the pH to normal, metal concentrations will still remain at levels toxic to fish. Also, the neutralizing effects wear off in 3 to 4 years. Liming may be a short-term remedy, but it is not a solution. Consider the logistics of dumping tons of lime into the thousands of lakes in Canada and portions of the U.S..

Asha/Curtis Verma, age 35, Representative for Specific Motors of Minnesota
You will point out that the President's Council on Environmental Quality stated that "insufficient knowledge exists about the explicit causes and total effects of acid rain . . ." Any new and unnecessary pollution control measures required of industries such as yours could have devastating effects on the industry and eventually the national economy. You would be forced to pass the costs of pollution control on to the consumer. You remind the commission that the costs of pollution control are not only direct but also indirect because your suppliers pass on their added costs to you. With the increase in Japanese and European automobile production, North American industries can remain competitive only by keeping production costs down. You will point out to the commission that any acid rain legislation would affect all parts of society.

Therese/Theodore Cummiskey, age 45, President of Ulster County Paper Products, Inc.
Most of the areas from which your company gets timber are located in regions where the pH of precipitation ranges from 4.2 to 4.6, as identified by the United States Geological Survey. Rain of this acidity is reported to reduce tree growth and to kill many plant species, including some of the pines that are the mainstay of your industry. Because the forestry industry is your livelihood, you want the commission to recommend immediate restrictions on sources of SO_2 and NO_x, such as certain industries and coal-fired power plants. If acid rain is not reduced to some extent, you can expect serious soil and forest effects in the next 25 to 100 years.

Nancy/Brent Biegel, age 42, Freelance Writer working on an article on acid rain
Although as a writer you try to remain objective, you have uncovered certain facts about acid rain that you think will interest the commission. The causes of acid rain include not only industrial pollution, but also automobile emissions, which account for much of the locally produced acid rain. Tall smokestacks built by utilities and industries reduce local pollution but transport acid droplets over great distances. Such information on dispersion should be useful in developing solutions to the problem.

Jeannine/George Lehman, age 37, Professor of Ecology at Cornell University, New York
You would like to make the commission aware that acid rain threatens the environment and ultimately human health. Studies have shown a direct relationship between the severity of health problems and the level of air pollution as measured by the concentrations of suspended particulate matter, especially sulfates and SO_2 in industrial and urban settings. Acidification of water supplies could release metals from rocks, soils, or plumbing. In addition, the inhalation of sulfur particulates may cause chronic bronchitis and emphysema. Although none of these assertions have been proven, some evidence supports the validity of these hypotheses.

Variation:

- An alternative means of conducting a debate would be to have the students adopt a point of view and conduct research to support their stands. They could then substantiate their claims with references and develop visual aids to accompany their presentations.

Watershed Discussion Questions:

- How do your personal actions contribute to the acid rain problem?
- How can your individual actions help to solve the acid rain problem?
- Why should we worry about acid rain in the Catskills since there is very little industry in those counties that contribute to acid deposition?

Source: Adapted from Living Lightly on the Planet, Volume II, Grades 10-12, through arrangement with Schlitz Audubon Center of the national Audubon Society, 1111 East Brown Deer Road, Milwaukee, WI 53217. Copyrighted material. All rights reserved.

It All Adds Up

Grades: elementary and middle
Objective: to illustrate the concept of biological amplification of toxins in an ecosystem
Subjects: Earth and Life Sciences, Chemistry, Math, Social Studies, Health

Materials: A large playing area suitable for a tag game, four cones or boundary markers, three inner tubes, one small bucket, 100 one inch square pieces of paper, a red marker

Information:

"Dibromocholoropropane, DBCP's have been called the pineapple pesticide, but the truth of the matter is that DBCP was used on more than 40 crops . . . Even though it was banned from use in the continental U.S. in 1979, it's still showing up." - *On Tap, Drinking Water News for America's Small Communities*, 1994, Morgantown, WV

Persistent pesticide compounds are noted for their ability to become biologically concentrated in a food chain. (See *The Bioaccumulation of Toxins)* A well-documented example of the effects of a chemical's biological amplification can be seen at Clear Lake, California during the time the pesticide DDT was in common use.

DDT was applied in very dilute quantities to the area in order to kill gnats. The concentration used was one part insecticide to 50 million parts of water with several treatments over eight years. It killed the gnats, but the effects of the toxin proved to be much more far reaching. Later, the chemical was found concentrated in the water plankton in the lake with a concentration of 250 times the original dose. Through further examination, the small fish of the lake were found to have a concentration of the chemical 500 times the original dose. And the Western Grebes, the birds that consumed the fish, were found to have concentrations of the pesticides 80,000 times the original dosage. Though they were not the target of the pesticides, 2,000 fish-eating birds were reported killed.

Students faced with numbers such as these are often consumed by the amounts, disregarding the causes. The following active game will dramatically illustrate the effects of biological amplification of toxins to the group involving them in a depiction of the process itself.

Procedures:

1. The strength of this activity lays in not telling the group about the accumulation of the chemicals at first, but rather focusing on the food chain being played out. Begin by setting up a long rectangular playing area that is free of hazards to a running student. Place the three inner tubes in different locations in the area. The boundaries should be wide enough to line up the entire group across one end.

2. With the group standing together at one end of the playing area, explain to them the boundaries and the following rules. The game is designed to play out three links of a familiar aquatic food chain. When the game begins, everyone will be fish swimming from one end of the pond to the other. Place a small bucket of paper pieces at the far end of the pond. (Note: Before the activity time period, secretly mark 50 of the pieces with a small red dot.) The paper pieces represent the fish's food source, plankton.

3. During the game, the fish must run to the far end of the pond and take one piece of food from the bucket, returning to the starting point before heading back to take another. They will have a set time period to gather as much food as they can to survive. During this time, they must also avoid being eaten by a predator. Designate one student to be a grebe (a fish-eating bird). If the grebe tags a fish in the game or runs them out of the pond, the fish must give the food they have to the grebe and wait out the remainder of the game in "fish heaven" for they have been eaten.

4. There are several things a fish can do to avoid the grebes. They may swim (run) very fast, wait in the safety of their homes and feeding grounds (the ends of the area) or they may hide in holes and under rock (by placing one foot into one of the inner tubes).

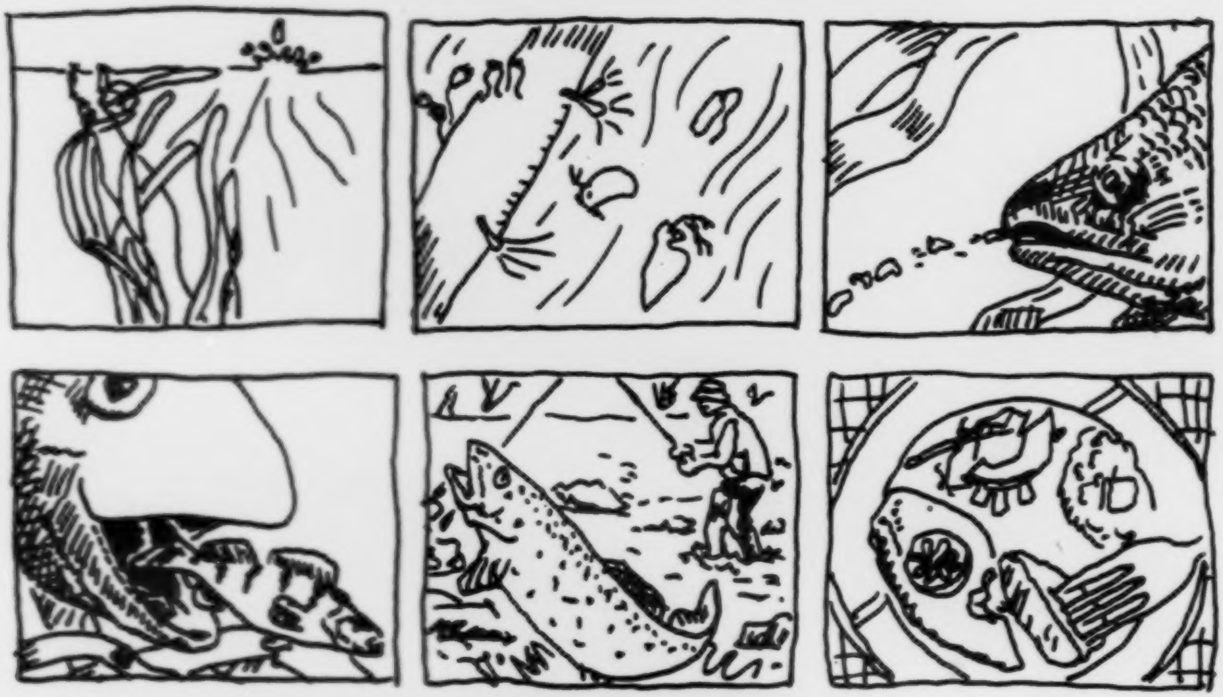
5. Give the group the opportunity to play out the food chain for three to five minutes.

6. After the time is finished and everyone has caught their breath, instruct the students to count the amount of food energy tickets they were able to acquire.

7. Once the group has calculated if they had enough food to survive, it is time to mention the red dots. The dots represent plankton that have taken DDT into their tissues from the substances they eat. Ask the grebe and each surviving fish to inventory their paper pieces. The discovery of the fact that the grebe has accumulated more toxins than the individual fish is a wonderful lead-in to the story of Clear Lake, California and the effects of biological amplification of toxins on an aquatic ecosystem.

Watershed Discussion Questions:

- Why are these chemicals still showing up if they haven't been used here since 1979?
- What are the dangers to us if these chemicals accumulate in the food chains?
- What alternatives do we have to these pesticides and other persistent chemicals?



Catskill Community Solutions to Water Pollution

"Plans are the dreams of the wise." - *A German Proverb*

Protecting a water supply through community and citizen participation often is a good way of insuring water quality. People protect against contamination of water sources for a variety of reasons from federal and state regulations to village zoning laws. But the most compelling of reasons for avoiding water pollution is often for personal health and local pride. A family living in the town of Denning, New York, a community deep in the heart of one of the Catskill Mountain watersheds for New York City's drinking water supply adheres to the zoning and water quality regulations of the federal, state, New York City and county authorities. Yet the family's actions are also motivated by concern for their own health and home as well as local pride. The following are excellent examples of citizens working toward community solutions to water pollution are currently practiced within the Catskill Mountain Watersheds.

Pollution Prevention Through Watershed Management

At first glance, the towns of Denning and Neversink, New York, seem to be unlikely places for environmental threats. The town of Denning is made up of 68,515 acres with only 524 residents. This translates to less than five people per square mile. The entire town is in the Catskill Park with almost 65% of the land owned by the state of New York. While large scale pollution seems unlikely in this area, it is important to note that every stream feeding the Rondout Reservoir and most waterways feeding the Neversink Reservoir of New York City's water supply originate in the town of Denning.

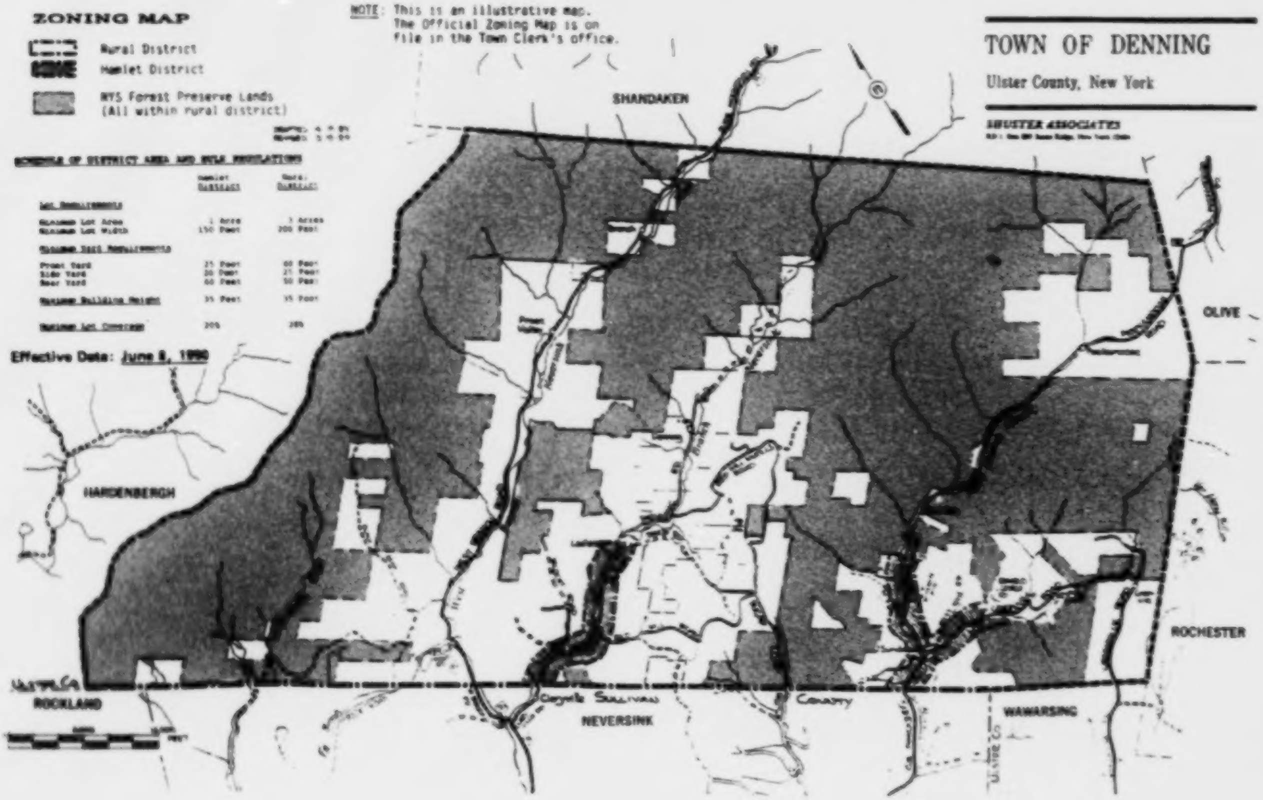
The town of Neversink, located in the northeast corner of Sullivan County, contains the Neversink and part of the Rondout Reservoir within its borders. Like the smaller town of Denning, Neversink is primarily rural and sparsely developed with limited roadways.

In September of 1990, the Citizens' Advisory Committees of these two towns began to pool their knowledge and resources to insure the continued high quality of their waters. With the volunteer contributions of resource people and authors from both local citizens and Ulster and Sullivan County authorities as well as the New York State Department of Environmental Conservation, Cornell University and the Cornell Cooperative Extension of Sullivan County, the town advisory committees were able to assemble a guide titled Pollution Prevention Through Watershed Management in Sullivan and Ulster Counties, New York.

In the guide's own words, "The purpose of this handbook is to provide a tool for locally based educational programs on water resources protection through pollution prevention activities. It provides background information about various sources of pollution and discusses solutions that can be used in preventing further pollution in the watershed." This extensive guide targeted towards concerned local citizens, town officials and county level agencies includes information on watershed management and planning, legal frameworks, community case studies as well as information on septic systems, storage practices, stormwater management and erosion control, groundwater, water wells and forestry practices.

With the handbook now assembled and published, the committees' next goal is to have the principles laid out in the guide recognized by the targeted audiences and the New York City Department of Environmental Protection (DEP) which has regulatory authority under the State Public Health Law to impose restrictions and requirements over potentially polluting activities in the Catskill Mountain watersheds.

In addition to the cooperative efforts put into the production of this resource, the towns of Denning and Neversink again joined forces for the sake of water quality in 1992. At that time, the Citizen's Advisory Committees (CACs) of the communities produced questionnaires for the local residents to inquire into their current water and sewage practices, community planning issues and as well as general biographical information about the populations. The responses were informational and encouraging with 87% of the responding participants in Denning interested in learning more about the town's Whole Community Planning and water quality issues. In 1993, the partnered CACs of Denning and Neversink built on this project by creating The Neversink Reservoir Watershed Protection Council Proposal for the protection from contamination, degradation, and pollution of the Neversink Reservoir and its sources. Recognizing the need for educational efforts in the area, the towns also created a Whole Community Planning Education Proposal working with the Cornell Cooperaive Extension of Sullivan County. This proposal notes the immediate need for working relationships between CACs, watershed residents and designated agencies. Laid-out in this proposal are long term educational processes involving youth and area residents in providing a work force that knows and understands the issues regarding water quality.


ZONING MAP
Rural District
Hamlet District
NYS Forest Preserve Lands (All within rural district)
NOTE: This is an illustrative map. The Official Zoning Map is on file in the Town Clerk's office.
Effective Date: June 8, 1990
TOWN OF DENNING
Ulster County, New York
SHANDAKEN
OLIVE
HARDENBERGH
ROCHESTER
ROCKLAND
NEVERSINK
WAWARSING
Sullivan County

The Watershed Agricultural Plan

Motivated by New York City's concern for regulations on agricultural practices in their watershed, the Watershed Agricultural Council of the New York City Watersheds, Inc. and the NYC DEP have initiated a voluntary, locally developed and administered program for best land management practices. Since 1992, this group has been developing and implementing "whole farm plans" for agricultural businesses in the watershed based on scientific research and technical data using ten pioneering farms in five different counties.

This Watershed Agricultural Program bases its efforts on the foundation that well-managed agriculture in a populated, rural landscape is a superior way to protect water quality. The program strives to do the following:

- meet water quality protection policies established by government agencies;
- involve farmers voluntarily using incentives to participate;
- foster a vibrant agricultural economy in the region allowing farming to compete with other land use demands;
- build water quality protection around the core of well-managed farms;
- uphold a willful and negligent clause in the regulations for farmers;
- and maintain leadership of the program locally in the watershed communities.

Guided by their "Whole Farm Plans", the program's partnerships between individual farmers and New York City apply and test multiple ways of managing pathogens, nutrients, sediments, pesticides and other environmental sensitivities. Thus far, the program has developed and implemented several demonstration designs for the ten cooperating farms with plans for expanding these projects in the following years. In 1995 over fifty farms will begin whole farm planning and implement best management practices to protect their water quality.

To learn more . . .

For more about the Pollution Prevention Through Watershed Management in Sullivan and Ulster Counties, New York Handbook, contact Kyle Babbit-Myers, The Cornell Cooperative Extension of Sullivan County, 69 Ferndale-Loomis Road, Liberty, NY 12754, (914)292-6180.

To find out more about the Watershed Agricultural Council's current programs, contact Richard I. Coombe, Chair of the Watershed Agricultural Council of New York City Watersheds at RR. 1, Box 74, NYS Rte. 10, Walton, NY 13856, (607) 865-7790.

Picking A Place To Plant

Grades: middle and upper
Objective: to investigate the characteristics of healthy soils
Subjects: Earth and Life Sciences, Social Studies, Chemistry, Health, Economics

Materials: *Possible Planting Locations* information copied onto separate pieces of paper

Information:

"In our every deliberation, we must consider the impact of our decisions on the next seven generations." - *Iroquois Confederation*, 18th century attributed

In considering the wise use of United States' lands, the National Resource Conservation Service set up a Land Capability Classification as a guideline to local and state soil and water conservation districts. Though it relies on voluntary compliance to these guidelines, the NRCS does provide technical and economic assistance through their district offices for efforts in reducing erosion and encouraging judicious use of soils. The classification recommended by the NRCS characterizes land into two categories, land suitable for cultivation and land not suitable for cultivation. Examples of land suitable for cultivation in this system and their recommended primary uses are as follows:

Land Characteristics	Primary Uses
Excellent, flat, well-drained land	Agriculture
Good land with minor limitations such as slight slope, sandy soil, poor drainage	Agriculture, Pasture
Moderately good land with important limitations of soil, slope or drainage	Agriculture, Pasture, Watershed
Fair land, severe limitation of soil, slope or drainage	Pasture, Orchards, Limited Agriculture, Urban Industry

Under this system, land not suitable for cultivation is recommended for grazing, forestry, watersheds, industry, recreation, aesthetics and wildlife.

The following role play activity will give your students a closer look at the variables to consider in planning a potential location for cultivating plants.

Procedures:

1. As a follow-up for lessons on soils and community development, introduce this activity as a chance to role play a common land use discussion and decision. In this activity, everyone will be playing the roles of members of the community of Watershedville.

2. Separate the class into 5 equal groups. Each group of students will be given a role and task in this community. Explain to the class that the situation at hand is the Community Club of Watershedville received a donation of flowering shrubs. They are now having a meeting to talk about where to plant them. Four possible locations have been suggested and the owners of these places are attending the meeting to encourage the club to decide on their

site for the plantings. All four places in deliberation get the same amount of sunlight and rain and are located where a lot of people will see and enjoy the shrubs. The club doesn't have any money or time for fertilizing efforts, so they want to plant the shrubs where they'll get plenty of nutrients naturally.

3. The roles available in this activity are the four different land owner groups and members of the community club. When the meeting begins, each of the owners groups will be given the opportunity to present to the club members the reasons that their location would be best for the shrubs. The club members will be given an opportunity to ask questions of the owners so the groups will need some time to look over the information on their particular location and brainstorm on possible pitches for their presentations.

4. Start by assigning one group the roles of the community club members. Encourage them to take some time to decide what they are looking for in a planting location. Next, assign each of the other groups the roles of the land owners and supervisors. Give them some time to look over and discuss the information on their locations.

5. Once everyone has had ample time to prepare, have the community club member call the meeting to order. Encourage the club members to run the meeting giving consideration to all of the groups and their presentations and allowing for questions and answers. At the end of the meeting, ask the members for their decision and the reasoning behind it. Discuss with the class the possible outcomes as well as the difficulty in making planning decisions such as this one.

Possible Planting Locations

Group 1 - Renchler Forest Owners

This site was a small forest. The town recently cut it down leaving the logs, leaves and branches on the ground. A lot of mushrooms grow here.

Pros

- lots of dead plants are there to provide nutrients
- mushrooms and other decomposers are breaking down the dead plants and releasing nutrients

Cons

- logs and branches don't break down very quickly
- it could be hard to clear the site to make room for the shrubs

Group 2 - Green Acres Garden Owners

This site used to be a community garden. Four families shared it and grew vegetables here for ten years. They stopped using it three years ago. Now a lot of tall weeds grow here.

Pros

- there might still be fertilizer or compost in the ground
- some of the garden plants might have rotted and returned to the soil
- the land has been worked so it will be easy to plant in it
- tall weeds could mean the soil is good

Cons

- harvesting garden plants might have used up all the nutrients in the soil
- some weeds grow best in poor soil, so weeds could mean that the soil is low in nutrients
- could be hard to get rid of the weeds
- pesticides in the soil might have killed some of the decomposers that recycle nutrients.

Group 3 - The Office District Owners

This site used to have an office building on it. The building was torn down about a year ago. All parts of the building were taken away. Now the ground is bare.

Pros

- the ground is bare so it would be easy to plant the shrubs

Cons

- probably all of the topsoil which contains most of the nutrients for plants was scraped away in building and destroying the offices
- since nothing has grown there in a year since the building came down, the soil must be low in nutrients or toxic

Group 4 - The Town Lot Supervisors

This site is where the town crew dumps the leaves it collects from lawns. The crew spreads the leaves over the lot. The ground now has a layer of leaves about 15 centimeters deep.

Pros

- leaves at the bottom of the layer are probably decomposing and returning nutrients to the soil
- leaves could stay around the shrubs once they are planted to keep weeds from growing up and continue to provide nutrients for the shrubs

Cons

- it has been so long since this project began, no one is sure what is under the leaves - if it is pavement, it would not be good for the shrubs
- it could be a lot of work to clear away the leaves to make room for the shrubs
- the town may then need to find a new place to dump leaves

Variation:

- Using the site informations as guides, create miniature sites in flower pots or boxes to test the success for small plantings in each location.

Watershed Discussion Questions:

- What are some of the different ways in which nutrients can leave an area?
- What are some of the different ways in which people are able to add the nutrients back into an area?
- How are some of these methods better for a watershed than others?

Source: Lessons adapted with permission from "Planting Preferences" pp. 314-323 in *Eco-Inquiry: A guide to ecological learning experiences for the upper elementary grades* by Kathleen Hogan, Kendall/Hunt Publishing Company, © Institute of Ecosystems Studies, 1994

Predacious Pesticides

Grades: elementary and middle
Objective: to explore an chemical-free method of pest control
Subjects: Earth and Life Sciences, Chemistry, Social Studies, Health

Materials: A large playing area, four cones or boundary markers, an insect field guide

Information:

"... Therefore, the focus must be on preventing the generation of persistent toxic substances in the first place, rather than trying to control their use, release and disposal after they are produced." - *International Joint Commission Sixth Biennial Report*

Humans share this planet with insects. No one is more aware of that fact than a farmer or gardener. Yet those who grow plants using organic methods have realized that keeping these organisms at bay need not require chemical warfare. Organic controls for pests use mechanical, botanical and biological methods rather than persistent and toxic compounds.

Successful mechanical methods of pest control include gooey gels, snares, traps and diatomaceous earth. Some botanical controls such as pyrethrum (an extract derived from the chrysanthemum daisy) or neighboring the plants with marigolds are quite effective on a wide variety of insect pests. Biological pest controls are commonly used with great success using natural predators to control the populations of pest insects.

Procedures:

1. After a class discussion on organic gardening methods of pest control, introduce this game as a means of getting to know the predators that gardeners use to protect their plants. Begin the game by setting up a long rectangular playing area for running. Split the class into two groups, arranging them in the center of the area in two parallel lines facing each other, three feet apart with the long lengths of the field behind them.
2. The rules to the game are as follows: This is a tag game. At the beginning of each round, the leader will assign each line an organism in a garden. The pairs chosen will be a predator and their pest prey. Once the pairs are announced, the leader will then count to ten. During this time, the students need to quickly decide if they are the predator or pest prey in the relationship. At the end of the count, the prey organisms need to run to safety beyond the boundary markers behind them. The predators need to tag as many prey as they can before they reach safety. Those students that were captured by the predators then remain in the game by joining the other team for the following round. The game continues with opportunities of explanation of the pest control relationships while everyone catches their breath. Some examples of gardening predator/prey relationships are:

Predators	Prey
Assassin Bugs, Damsel Bugs	Grubs
Bacillis popiliae (bacteria)	Japanese Beetle Grub
Ladybugs	Aphids
Praying Mantis	Caterpillars
Spiders	Leafhoppers

Watershed Discussion Questions:

- What are some ways to get rid of pests without using toxic chemicals?
- What methods of pest control do you use at home? Are they safe for your watershed?

Treating Our Wastewaters

Grades: elementary and middle
Objective: to discover two ways in which wastewater is treated
Subjects: Earth and Life Sciences, Chemistry, Social Studies, Health, Economics

Information:

"1/3 of the septic tanks in the U.S. are polluting water." - *National Wildlife Federation*

Where does the water go when it drains down our kitchen and bathroom sinks? It is surprising just how many people today do not know the answer to that question. To maintain safe ground and surface waters, wastewaters from our homes and businesses must go through some form of treatment before they are released into the environment. Household sewage is a combination of wastewater from several sources: our toilets - 40%, our laundry - 15%, our bathing - 30%, our kitchen - 10% and miscellaneous water uses - 5%. (Septic *Systems, 1989, University of NH Coop. Ext.*) Rural homes, such as in many small Catskill Mountain communities, often use septic systems. Larger villages and cities use wastewater plants or other forms of treatment to deal with their community's wastewaters.

Improperly or inadequately treated wastewaters can contaminate surface and groundwater supplies of drinking water. When wastewaters are treated correctly, dangerous contaminates are removed insuring the safety of the surrounding environment and the communities involved. The following experiments can be used to familiarize students with the specific steps taken in wastewater treatment systems for treating water safely and efficiently.

The Steps of a Wastewater Treatment Plant

Wastewater treatment plants go through several steps in a treatment process in order to safely treat large quantities of wastewaters. When the water first arrives at the treatment plant, it passes through a **comminutor**, which screens, grinds up and removes large floating objects like rags, sticks, cans, etc. After this screening process, the water passes through a **grit chamber**, where sand, grit, cinders, and small stones settle to the bottom. Once the screening is completed and the grit is removed, the sewage then moves on to the **sedimentation tank** where most of the solids settle to the bottom as raw sludge. The sludge is mechanically removed from the tank when necessary. These steps all constitute the first, or primary, stage of treatment.

In the past, this was often enough treatment for most communities. However, with the amounts and types of pollutants now entering our wastestreams, secondary measures are often needed. Secondary treatment takes the sewage after it leaves the sedimentation tanks and puts it into an **aeration tank**. Here the sewage is mixed with air and sludge loaded with bacteria and allowed to remain for several hours. During this time, the bacteria in the sludge break down any organic materials present in the water. The resulting sludge mixture is now teaming with millions of bacteria and can be used with new sewage in the presence of additional supplies of fresh air. The next secondary treatment commonly used after the wastewater leaves the aeration tanks is **chlorination** in which very small amounts of a chlorine gas are added to the water to kill any bacteria which may still be present. At this point the water is again given the opportunity to settle out any remaining particulates before it is discharged through a pipe into a nearby stream, river or ocean. There are several other methods for treating wastewaters for reuse, but the above mentioned techniques are the most commonly used.

The amount of processing a municipality uses on their wastewaters is mandated by the Federal Clean Water Act standards as well as New York State imposed effluent standards. Additional secondary treatments include combinations of aeration tanks or trickling filters with sedimentation tanks or the use of lagoons or wetlands using the natural ecosystems in order to absorb the impurities present. Advanced treatments, when necessary, include nutrient extraction, further filtration, disinfection and chlorine removal before the effluent is discharged or reused.

The Steps of a Septic System

These two-part systems generally consist of an underground watertight receptacle called a septic tank, a distribution or diversion box and a soil absorption or drainage field.

As wastewater leaves the home, it travels through pipes to the septic tank. Inside the tank, beneficial bacteria begin to break down some of the solids. The remaining heavy solids settle to the bottom of the tank and the lighter solids and grease float to the surface. This settling process inside the tank is called **sedimentation**. In order to maintain a quality performance inside the tank, the sludge and scum are periodically pumped out.

From the tank, sediment-free liquid then flows through pipes and a distribution box to perforated pipes in trenches. There the partially treated water flows through the surrounding crushed rocks or gravel and soil toward the groundwater. During its travels, bacteria, oxygen and soil help purify the water through chemical and physical reactions. This penetration process provides a form of **filtration**. Because the soil is the critical factor in the cleansing of the wastewater, it determines the type of system that can be installed.

Materials: Muddy water, two clear jars or bottles, one clear plastic 2-liter bottle, fine sand, coarse sand, pebbles, a small piece of wire screen

Procedures:

1. To demonstrate the primary stage treatment of sedimentation in a septic system and wastewater treatment plant, have the students fill one of the clear containers with shaken muddy water. Allow the particles to settle and observe the water every five minutes. Record the results.
2. To illustrate the filtration step, have the students cut the bottom off of a 2-liter plastic bottle. Invert the bottle and put a piece of wire screen on the bottom inside the neck. Next, place layers of clean soil materials in the filter bottle beginning with the coarsest materials such as pebbles, and ending with the fine sand on top. Run some tap water through the filter in order to clean it.
3. Slowly pour off half of the settled water into the filter bottle. Compare and record the resulting filtered water with the muddy water and with the remaining settled water.

Watershed Discussion Questions:

- How is your community's wastewater treated?
- What additional water treatment steps does your community take to ensure the safety of your drinking water supply? (i.e. testing, chlorination)

Sources: Information obtained and lessons adapted from *Wastewater Treatment Worksheet* in Captain Hydro Water Conservation Workbook and the Pollution Prevention Through Watershed Management in Sullivan and Ulster Counties, New York Handbook

The Pollution Sources of the Watersheds

Assessment Tools

Learning Logs and Evaluations

"Man is constantly adding to his knowledge of the world, but to do any good it must be shared - by the people." - *Author Unknown*

As students work together on science-based projects, many opportunities arise for active learning and collaborative group work. Both Learning Logs and Group Work Evaluations can serve as assessments of not only the student's comprehension of the subject material but also a gauge on the dynamics of the team or partner cooperative efforts. The following are some suggested questions and statements for class logs and evaluations that you can put together for an appraisal of your students' understanding of subjects on the pollution sources of the watersheds.

Learning Logs:

After working through an experiment or activity, have each student take some time to write down the information that he/she found interesting about the project, focusing in on the enthusiasm they may feel about exploring the subject further. Some examples would be:

What I now know about nonpoint source pollution . . .
What I wonder about this subject . . .
What I found out doing the experiment on acid rain . . .
What I want to try in a different acid rain experiment . . .
What I think I am good at in science . . .

Rapid Writes:

Rapid Writes are a way of checking students' comprehension of the information being presented. Taking care not to present these as pop quizzes, "writes" are meant to probe the students for understanding of the subject as well as possible tangent topics to follow-up on at a later time. Some examples of Rapid Writes questions would be:

What are we learning?
What questions do you have?
What are your thoughts about this subject?

Group Work Evaluations:

Many of the lessons we learn about cooperating in groups and how to work well with others come from developing these skills through experience. A non-accusatory evaluation of the group's trials and tribulations while working together is an excellent way for students to reflect and improve on their performances. Some examples of Group Work Evaluation questions would be:

What did your group accomplish? What helped your group work well?
What held your group back from doing more?
How could your group do better in the future?

The Pollution Sources of the Watersheds

Class Follow-up Projects

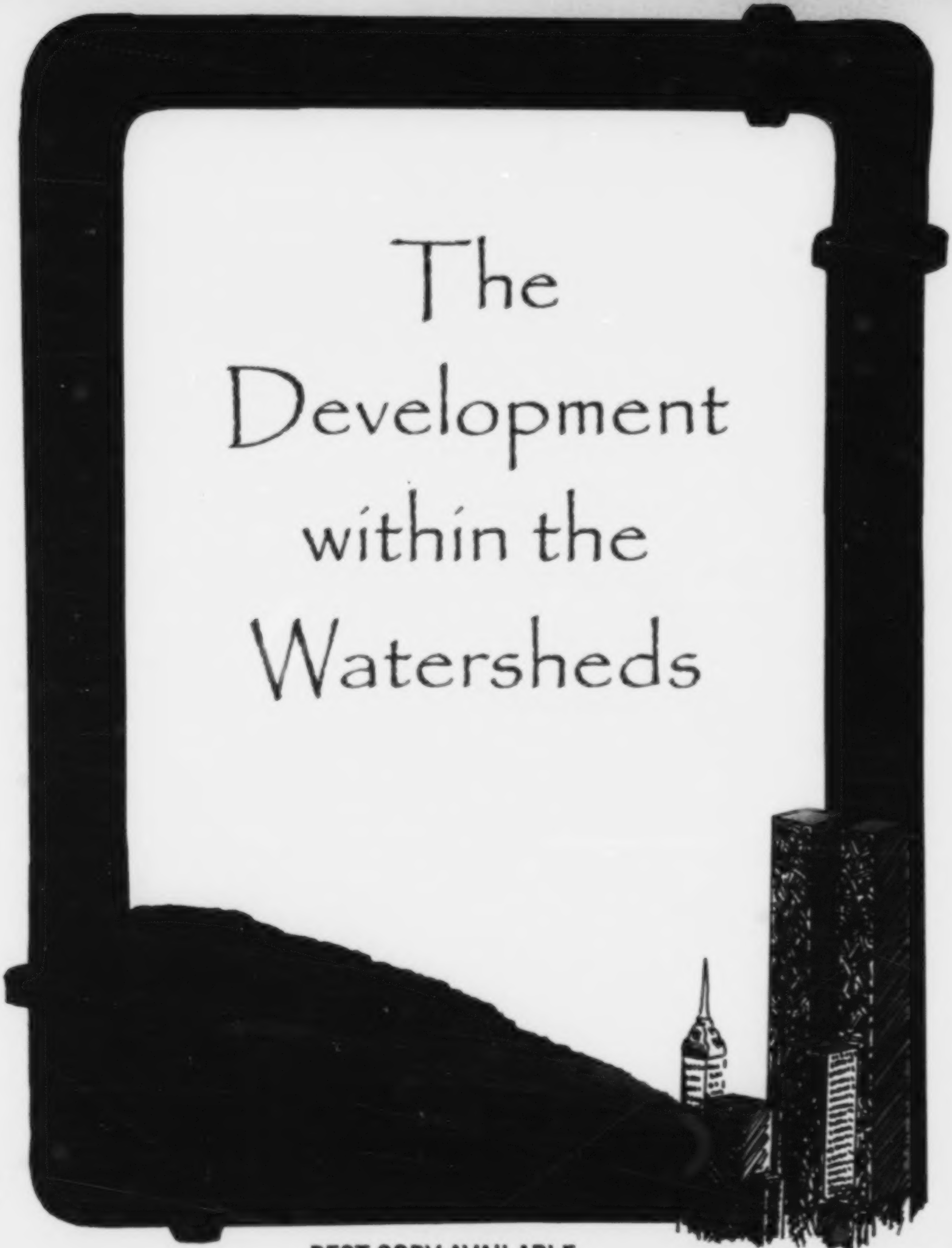
If after studying this section on The Pollution Sources of the Watersheds the class is eager to build on these lessons, here are some ideas for some successful follow-up trips and creative classroom projects involving in-depth looks at these environmental concerns.

Science Field Trips:

- **A closer look at on-going research** - A day or resident trip to the Frost Valley YMCA's Environmental Education Center will enable your class to take a closer look at the United States Geological Survey's on-going studies of acid deposition in the Catskills as well as studies measuring air quality and meteorology currently being researched by the Institute of Ecosystem Studies. Both studies are in cooperation with the YMCA and are unique opportunities to witness the methods and equipment used in these state-of-the-art research projects. - For more information contact the Director of Environmental Education at the YMCA at (914) 985-2291.
- **A trip for Green-Thumbers** - A day trip to one of your local organic farms, gardens or greenhouses provides an encouraging opportunity for students to explore not only organic methods of growing plants but also to see where their food comes from. The Frost Valley YMCA also has an organic greenhouse and gardens that work with their food waste composting center to provide vegetables, herbs and ornamental plants for their facilities. Classes in composting and organic gardening may be included in any educational visit to the YMCA.

In-school Projects:

- **Start your own chemical-free garden** - A fun cooperative science project in any season is assembling and caring for garden beds or flower boxes. Students can learn first hand about organic methods of plant care as they dig into their own botanical creations.
- **Explore the issues** - Organize a debate exploring a controversial environmental issue such as acid rain or nonpoint source pollution.
- **Catch someone's attention** - Encourage students to draw attention to an environmental issue by painting a mural on the school grounds depicting not only the cause of a pressing concern but also potential solutions. Suggested topics may include: water conservation, litter prevention or point source water pollution.



The Development within the Watersheds

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The Development Within The Watersheds

This section of our guide includes the following:

- information inserts - - on the subjects of sustainable development and the history of New York City's water supply
- a variety of activities exploring topics in defining watersheds, the effects of human communities' uses and misuses of water sources and how these dynamics affect the ways of the watersheds

Working With The Earth - Sustainable Development

Welcome to "Awayville"
to weigh the social, economic and ecological factors involved in maintaining a solid waste disposal system and the safety of a community's water supplies

Migration Mishaps
to illustrate the effects of habitat destruction on wildlife

Whose Water Is It? - A Case Study
to evaluate whether animals or people have more right to water bodies

From Wells to Watersheds
The History of New York City's Water Supply

New York Upstaters and Downstaters
to explore the sources, effects, and validity of New York generalizations and stereotypes

Water Rights Rivalries
to become familiar with the history of New York City's water supply system
to weigh the historic social and economic factors involved in the implementation of the Delaware and Catskill Reservoir Systems
to explore the land use management techniques in the Catskills past and present

The Watershed Whodunit
to learn how to use contour mapping in detecting groundwater flow and investigating the source of groundwater contamination

Assessment Tools

Class Follow-up Projects

Working With The Earth

Sustainable Development

> "The ecologization of politics requires us to acknowledge the priority of universal human values and make ecology part of education and instruction from an early age, molding a new, modern approach to nature and at the same time, give back to [us] a sense of being part of nature. No moral improvement of society is possible without that."
>
> *- Mikhail Gorbachev*

"Meeting the needs of the present without compromising the ability of future generations to meet their own needs." This is how the World Commission on Environment and Development defines sustainable development. Throughout the world, every culture has its own ways of developing societies which in turn have dynamic effects on that country's human, economical, technological, and environmental dimensions. Many reference materials provide lists of goals that are necessary to meet if a country is to adopt a policy of sustainable development. Yet there is no denying that these diverse actions are supported by universal laws, concepts and principles for understanding and working with the earth. Some examples of these underlying precepts are:

In Science

- Science is an attempt to discover order in nature and then use that knowledge to describe, explain, and predict what happens in nature.
- Life on earth depends on the flow of high-quality energy from the sun through earth's life support systems and eventually back into space as low-quality heat, gravity, and the recycling of vital chemicals by a combination of biological, geological, and chemical processes. (*the principle of energy flow, gravity and matter recycling*)
- Each species and each individual organism can tolerate only a certain range of environmental conditions. (*the range-of-tolerance concept*)
- Every species has a specific role to play in nature. (*the ecological-niche concept*)
- Over billions of years, a variety of species (species diversity), genetic variety within species (genetic diversity), and natural systems (ecosystem diversity) have evolved in response to environmental change. (*the concept of biodiversity*)
- Earth's life support systems can take much stress and abuse, but there are limits.
- We can never do merely one thing. Any intrusion into nature has numerous effects. Many (perhaps most) of them are unpredictable because of our limited understanding of how nature works. (*the first law of human ecology*)
- Our challenge is to discover which connections are the strongest and the most important to us and other species.

In Use of Our Resources

- Locally available perpetual and renewable resources should be used where possible. Renewable resources should be used no faster than they are replenished by natural processes. (*the concept of sustainable yield*)
- Pollution prevention and waste reduction are the best and cheapest ways to sustain the earth. The best way to reduce pollution and waste is to produce less. (the pr*inciple of pollution prevention and waste reduction*)
- Everyone is downwind or downstream from everybody. (*the principle of global commons*)

In Economics and Politics

- We should not deplete or degrade the earth's physical, chemical, and biological capital which supports all life and human economic activities.
- We cannot have economic and military security without environmental security; we cannot have a truly healthy economy in a sick environment.
- Anticipating and preventing problems is cheaper and more effective than reacting to and trying to cure them; an ounce of prevention is worth a pound of cure.
- We should think globally and act locally. (*the principle of change*)

In Our Ethical Guidelines

Working with the ecosphere and ecosystems

- When we alter nature to meet our needs or wants, we should choose the method that does the least possible harm to us and other living things.
- Before altering nature, we should carry out an Environmental Impact Analysis (EIA) and a Grandchild Impact Analysis (GIA) to help us decide whether or not to intervene and to also discover how to inflict the minimum of short- and long-term harm.

Working with species and cultures

- Every species has a right to live or to at least struggle to live, simply because it exists.
- The best way to protect species and individuals of species is to protect the ecosystems in which they live.
- No human culture should become extinct because of our actions.

Working with individual's responsibilities

- We should leave the earth in better shape than we found it by considering the impacts of our actions on the next seven generations. (*an ethical principle of some Native American cultures*)
- We should strive to live more lightly on the earth, not because of guilt or fear but because of a desire to make the world a better place. No one can do everything but we can do better by working with the earth.

Source: Adapted from an essay in Living In The Environment by G. Tyler Miller Jr.

Welcome to "Awayville"

Grades: middle and upper

Objective: to weigh the social, environmental, economic, and ecological factors involved in maintaining a community's solid waste disposal system and safe water supplies

Subjects: Earth and Life Sciences, Chemistry, Health, Economics, Gov't, Social Studies

Materials: *The Awayville Character Roles* copied and separated for student use

Information:

"Matter cannot be created or destroyed; it can only be changed from one form to another." - The law of conservation of matter Everything we think we have thrown away is still with us in one form or another; there is no away.

When people throw things "away", we often naively think that they are out of our lives. Yet, in the case of municipal landfills, for example, substances that we store away often come back to harm us in the future. Although municipal landfills are designed to accept solid non-toxic wastes, they do receive many toxic materials from household, municipal, commercial, and even industrial sources. These substances can then leach into our water supplies causing serious short and long-term effects.

Factors which influence the behavior and movement of contaminants in soils include: the slope of the land, soil characteristics (soil texture), soil depth, depth of the water table, texture of the unsaturated zone, type of aquifer material (permeability), the horizon distance between potential contamination sources, and water use points.

The following role play activity exposes students to the complexity of waste disposal choices by putting them into negotiations for the care of a community's solid waste stream.

Procedures:

1. After discussions and lessons on the topics of soils, water characteristics, waste disposal methods, and sustainable development, introduce this role play simulation to the class. Explain to the students that they will be taking part in a planning meeting for the management of a community's waste disposal system. Each of them will be given a role to play. During the activity, they may choose what they will say but they must stick to their assigned characters.

2. Assign each student an Awayville Character Role. All of the characters may have two people playing them except for the mayor.

3. Explain to the group the setting and situation in Awayville. The mayor needs to run the meeting and with the help of the other players, make a final decision on the use of the land in question. Before beginning, give the students time to study their roles and formulate a presentation for their character. Then, give the group ample time to discuss and debate the situation in the meeting.

4. After the meeting has adjourned, discuss with the group how they worked together and their feelings on this complicated subject.

"Awayville", U.S.A.

Awayville is a community on the banks of a beautiful pristine waterway. The water from their watershed is used for the community's homes, businesses, and farms before it continues on to supply New York City with much of its drinking water. The population of Awayville is small with the residents taking great pride in the quality of the environment which they live. The water that flows through this area is thought to be some of the cleanest in the country.

A town meeting has been called today to view a proposal for a new waste disposal system to be zoned in the waterfront area of the town. In attendance are the mayor, town board members, farmers, business owners, and representatives from Composter, Inc. and Landfills Are Us.

The town's current landfill is reaching its capacity and the community needs to evaluate the status of their methods and plan how they will be disposing of their wastes after the landfill closes next year. A large plot of land is available for the community to use for its waste. The land in debate today is a "wild" plot owned by the town upstream from the center of the community. Representatives from the two companies are here to make offers to the community for the use of this land for either a compost/recycling center or another landfill. The mayor will take this time to hear everyone's words on the subject before he/she makes a decision on the new waste disposal system. Everyone in attendance has come to voice their opinions on the plans. Many have gathered information from what has happened to other communities in similar situations in the past.

The "Awayville" Character Roles

The Representatives from Landfills Are Us

This community is perfect for your new landfill site. There are many unemployed workers for your workforce. Also, the community is centrally located near many other towns needing a disposal alternative and there are few environmental regulations set in place here. You also have a good history in the area with the current landfill in this community. You feel that once the new landfill is in full operation, you can provide a good system for the town with competitive tipping fees and a dependable means of waste disposal.

The Representatives from Composters, Inc.

This community is perfect for your new Compost/Recycling Center. There are many unemployed workers for your workforce. The community is centrally located near many Material Recovery Centers (recyclables clients) and farmers and landscapers (compost clients). There are also very few environmental regulations set in place for this area. You feel that once the center is in full operation, you can provide a good waste disposal system for the town with competitive tipping fees and potential income from the sale of compost and recyclables.

The Mayor and Board Members

As representatives of the people of Awayville, you are anxious to bring businesses into the area that can employ many of your people and produce more income (and a larger tax base) for your community. With added income, you can improve the schools and transportation systems, build new housing areas, and bring more people into the area. The health of your community is also an important issue for you. You want to know which method is the best for your community's health, economics, and environment. Since you are elected officials and this is an election year, you will vote in whichever direction the majority of the population chooses.

The Environmentalists

Knowing the importance of the area this community chooses to build their waste disposal system on, you are here to warn the people of Awayville. The area near the waterway is an important wetland for the ecology of the area. Losing this habitat would have a disastrous effect on the wildlife of the area. You also feel that a new landfill will reach capacity some day and cause this whole situation once again. There are also dangers in improper waste disposal and product transportation that you feel the people of the community should consider in making a decision on this project. If you had to choose, you would caution people against the landfill because of the industry's history in land and water contamination.

This happened somewhere else:

- A marsh is set aside in NYC as a wildlife sanctuary after environmental groups defeat plans for an industrial park. (Joseph P. Fried, "After a long battle, a Queens tract of marshes became a park preserve.", Nov. 1990)

The Farmers

You have a small farm in the community that has been in your family for generations. Your concern about the landfill moving into that area is the effect it will have on the waterways and groundwater you depend on to irrigate your crops.

This happened somewhere else:

- Communities on Long Island, New York, no longer allow the use landfills on the Island for fear of further contaminating their susceptable groundwater supplies.

The People in the Town's Fishing Industry

You have a successful family-run fishing business here in the community. Realizing that you depend on the fish supply, you are very interested in the effects of the new system on the ecology of the waterway.

This happened somewhere else:

- The sale of shellfish is restricted after tests reveal unsafe levels of toxic industrial chemicals. (The James River in Virginia near the Chesapeake Bay was closed to oystering because oysters were contaminated with keptone in the 1980s.)
- Tests reveal deposits of toxic metals on the floor of the bay near a chemical plant closed 10 years ago. (Allied Chemical Plant in Baltimore's Inner Harbor, Maryland, 1990)
- The average catch of fish drops drastically after sediment from upstream logging and erosion cloud river waters. (A study in Bacuit Bay in the Philippines showed that a loss of both coral reefs and fish followed heavy sedimentation by soil eroded from logged hillsides., 1992)

The Long-time Residents of the Community

You and your family have lived in this community for many generations. The town has always been small and rural and you prefer that it stays simple. You feel that having to separate and pay attention to your garbage will be too much trouble and you don't have time for it. You are here to encourage the town to continue using landfills for your wastes.

The Landfill Workers

You have been employed at this community's landfill for some time now. It is very important that you keep this job (any job) so that you are able to take care of your family. Once the landfill closes, you hope to get a job in the construction of either the new landfill or the composting/recycling center, continuing with the company once the operation is underway.

The Town Water Inspectors

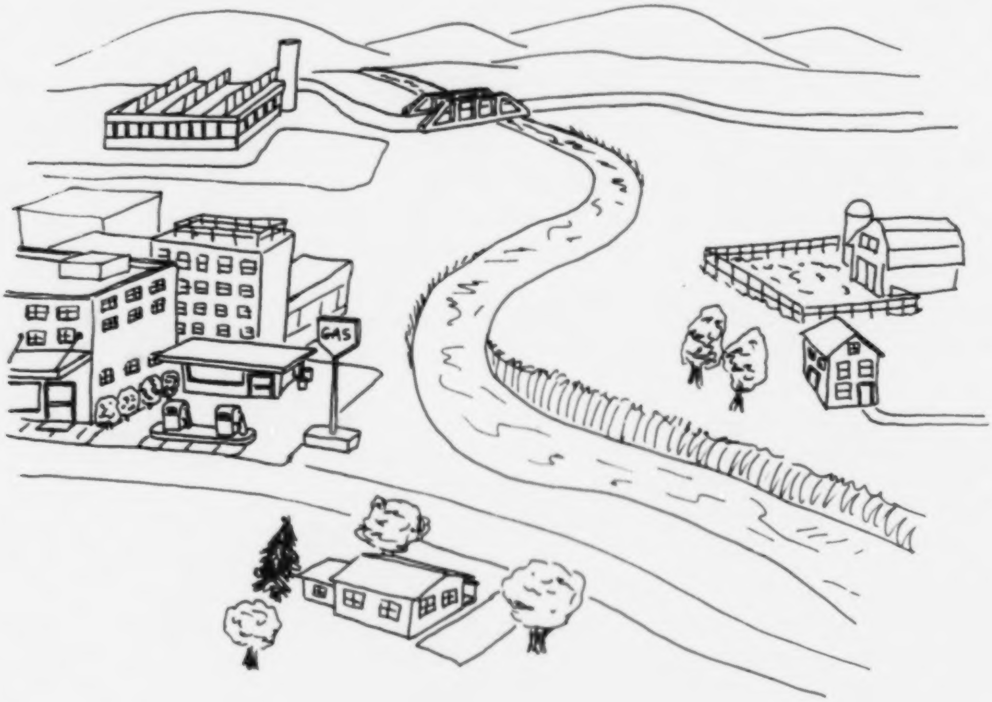
It is your job to watch the quality of the community's drinking water sources. Since both systems have the potential of contaminating the groundwater, you are concerned about how each company will handle its leachate and water run-off.

This happened somewhere else:

- The owner of a small factory is found guilty of illegally dumping nitric acid into sewers. (The owner of a small factory in Burlington, Massachusetts, was convicted of pouring nitric acid and nickel wastes down a sink. Charges were brought by the Environmental Protection Agency's criminal enforcement division. Some states are also acting: Massachusetts has formed an Environmental Crimes Strike Force. David Stipp, Toxic Turpitude: Environmental Crime Can Land Executives in Prison These Days", Wall Street Journal, Sep. 10, 1990)
- A study of the local coastline reveals many pipes were draining raw sewage into the river. (New York City, 1991 - A two and a half year survey by the City Department of Environmental Protection found 171 pipes discharging a total of about 4.5 million gallons of untreated sewage a day. About two-thirds of these pipes were city owned and, the rest were owned by private companies or other government agencies.)
- During 1994, several communities in the Catskill regions of New York State have encountered threats to their groundwater supplies from improperly closed and run landfills. These towns include Norrowsburg, Sidney and Rosendale.

Watershed Discussion Questions:

- How is Awayville's watershed similar to New York City's watersheds in the Catskills?
- What are some examples of other human actions that can contaminate a water supply?
- Name some precautions that industries often take to insure the safety of water supplies.



Migration Mishaps

Grades: elementary and middle
Objective: to illustrate the effects of habitat destruction on wildlife
Subjects: Earth and Life Sciences, Social Studies

Materials: A large playing area, 4 boundary markers, 2 carpet squares for every student

Information:

"The object of our game with nature is not to win, but to keep playing." - *Unknown*

The greatest threat to most wildlife species is a loss of their habitat. Human actions routinely disrupt migration routes and destroy breeding areas and food sources. Because many people see wetlands as wasted land rather than the ecological treasures they are, these aquatic habitats are being dredged, filled in and paved over at an alarming rate. Since 1980, approximately 55% of the coastal and inland wetlands in the continental United States have been lost to development and agricultural uses. It is said that each year in the United States, 1,200 square kilometers (470 square miles) of inland wetlands are lost to agriculture, mining, forestry, oil and gas extraction, highways and urban development. Furthermore, much of the remaining habitats are becoming fragmented or threatened by pollution at alarming rates.

Scientists are now saying that at least 500 of the U.S. native species have been driven to extinction and others are near ruin due mostly to habitat loss. This destruction is amplified dramatically when we consider the effects of habitat loss on migrating species. The following active game will illustrate to students the consequences of poor development practices on aquatic habitats and thus their dependent wildlife species.

Procedures:

1. After the class has an understanding of migration habits of wildlife species, introduce to them the concept of habitat destruction and its consequences. Begin the game by setting up a long rectangular playing area that is free of hazards to a running student. The boundaries should be wide enough to line up the entire group across one end. At both ends of the playing area, place a line of carpet squares (one for every student).
2. With the group standing together at one end of the playing area, explain to them that they are each standing on a habitat that supplies all of the food and environmental needs they may require. Down on the other end of the area, they will find another square habitat that they may run down to (migrate) and claim during different seasons.
3. This migrating back and forth can continue indefinitely. As you call out the seasons of the year, announce to them that this year one of the wetlands has been developed into a shopping mall (take one square away). Next, announce a migration to the limited number of habitats. The animals that do not find a habitat of their own need to share with someone else. As the game continues, keep removing habitats at either end announcing the reasons for the losses. As the students begin to pile up on the existing habitats you may either limit the number of species that are able to survive on a plot or let them naturally crowd each other out. Continue the game until you feel the lesson is evident to the students. Lead the group into a discussion on the consequences of habitat loss on wildlife species.

Watershed Discussion Questions:

- What are the wildlife habitats in your community? What species use them?
- How has the development of your community affected these species?

Whose Water Is It? A Case Study

Grades: all grades
Objective: to evaluate whether animals or people have more right to water bodies
Subjects: Earth and Life Sciences, Government, Economics, and Social Studies

Materials: A copy of Whose Water Is It? case study for each student, black board, chalk

Information:

"The time is always right to do what is right." - *Martin Luther King Jr.*

This activity is based on a true story about an endangered fish, the snail darter, that almost halted the enormous Tellico Dam Project in Tennessee. The voice of Gloria Lee in the story is fictional, but the story she tells really did happen. The Snail Darter vs. the Tennessee Valley Authority case study is an interesting story for students to investigate when exploring the controversy of animal vs. human rights to water sources.

The Tennessee Valley Authority (TVA) began the Tellico Dam Project in the late 1960s. Many people considered the project ill-conceived and tried to stop it. Quite by chance, snail darters were discovered at the dam site the same year the Endagered Species Act was passed. Snail Darters used to live throughout eastern Tennessee rivers, but so many dams had been built in the region that this area of the Little Tennessee River seemed to be the only place the fish could live. Concerned citizens tried to use the new Endangered Species Act to stop the project. The following is a summary of the major events of this controversy.

1960s	The TVA began the Tellico Dam Project in the lower Little Tennessee River.
1971	The local people successfully sued to stop the project on grounds that the TVA had failed to file an environmental impact statement.
1973	A University of Tennessee biologist discovered the Snail Darter in the fast waters above the dam site. This fish was a previously unknown member of the perch family. Filling the dam's reservoir would completely destroy its habitat. Coincidentally, Congress passed the Endangered Species Act to protect endangered or threatened species. Under the law, all federal agencies must ensure that their projects do not harm any endangered species or its habitat. The TVA then produced an environmental impact statement and accelerated construction of the dam.
1975	Citizens petitioned to put the Snail Darter on the Endangered Species List and thus under protection of the act. Subsequently, the Snail Darter was listed as an endangered species. The TVA tried unsuccessfully to transplant the fish.
1976	Citizens filed a suit against the TVA in the Federal District Court. The TVA, stated that although the evidence indicated that Snail Darters were likely to become extinct because of the dam, the Act was never intended to stop a project that was already 80% complete.
1977	Considering citizen's appeal, the sixth circuit court agreed unanimously with the Tellico opponents and ordered an injunction against further dam work.

1978 The U.S. Supreme Court upheld the injunction in a 5 to 3 vote because of the wording of the act.

Congress passed an amendment to the act that created an Endangered Species Committee, which would be convened to resolve "irresolvable" conflicts when other efforts had failed. This committee could grant exemptions to the act where no "reasonable and prudent" alternatives exist, when the project is of national and regional significance, or when the benefits "clearly outweigh" those of alternative action.

1979 The first case to be reviewed by the new committee was the Tellico Project. The committee ruled unanimously in favor of the Snail Darter, mostly because even though the dam was 95% complete, the committee decided it was more economical to stop the project than to continue.

A rider was added to the House Water Projects Appropriation Bill that exempted the Tellico project from all federal laws, and was passed without floor discussion. The bill narrowly passed in the Senate. It was signed, and 12 hours later the dam builders were back at work.

As predicted, the building of the dam completely destroyed the Snail Darters' habitat in the lower Little Tennessee River. Before the dam was complete, the Snail Darter was one of the most abundant species in the lower 20 miles of the river with about 5,000 individuals. Snail Darters have not been seen there since.

However, there is good news. Snail Darters have been discovered in other locations. Although transplanting efforts were unsuccessful, Snail Darter populations have been discovered in five other creeks and rivers in Tennessee. Apparently the fish had been living undiscovered in these other locations all along. In 1984, the Snail Darter was reclassified as threatened rather than endangered because of these findings.

Procedures:

1. Begin this activity by having the entire class work together to create two lists on the board: ways people use water and ways animals use water. The case study in this activity revolves around the building of a dam. Use this discussion to make certain that the students understand what a dam is and why people build them.

2. Next, lead a short discussion about water needs of humans versus those of other animals. What happens when these needs conflict? With their minds focused on that issue, give each student a copy of the case study story. Have the students read the story in pairs, taking turns reading paragraphs to each other. Give the partners time to discuss the questions at the end of the story.

3. Write the words "in favor of the dam project" and "in favor of the fish" on opposite ends of the blackboard. Then, ask the students to stand next to the phrase that most closely aligns with their opinion on how the story should have ended. If they are not feeling strongly in one particular direction, ask them to stand in the appropriate place on the gradiant between the two views that would illustrate where they stand in the decision. Are they leaning towards the fish but have some reservations? Then they should stand close to but not all the way at the fish end of the blackboard. Allow each student the opportunity to clarify why they have taken that particular stand.

The Little Fish Versus The Big Dam

Read the following story with your partner and answer the questions at the end.

My name is Gloria Lee and I'm in eighth grade. I want to tell you about a big conflict here in Tennessee and around the country, all because of a little fish.

Usually, it's quiet and peaceful here. My family and I live on a farm in a beautiful lush, green valley. The Little Tennessee River meanders through our valley making the soil rich, fertile, and good for farming. In fact, the whole valley is filled with little farms and pretty white clapboard houses like my family's. I think this valley is a wonderful place to live, but I'm not the only one who has thought so. Some archaeologists found Indian sites that prove people have been living here for 10,000 years!

The river is one of the things I like best here. When I want to be alone, I like to paddle around the river in our canoe, just sitting, thinking, and sometimes doing some fishing. As everyone around here knows, the Little Tennessee River has the best trout fishing in Eastern Tennessee, but it's not a trout that caused the commotion I'm going to tell you about.

It all started about 16 years ago when the Tennessee Valley Authority, or the TVA as we call it, decided to build a big dam here in our valley. The TVA said that the dam would use the water running through it to produce electricity. The TVA also said that the dam would help control the flooding we sometimes have. While the dam would back up the river and cause it to flood half the valley, it would make a big reservoir and recreation area where people could boat, fish, and swim. This Tellico Dam would cost 120 million dollars.

Some people liked the idea of a reservoir where they could water-ski and boat, but as you might guess, other people weren't too happy about having their homes and farms flooded to make a big reservoir. And it wasn't just their farms they wanted to save, it was the beautiful valley and the Indian sites, too. These people fought hard to keep the dam from happening. But the TVA fought harder, and won.

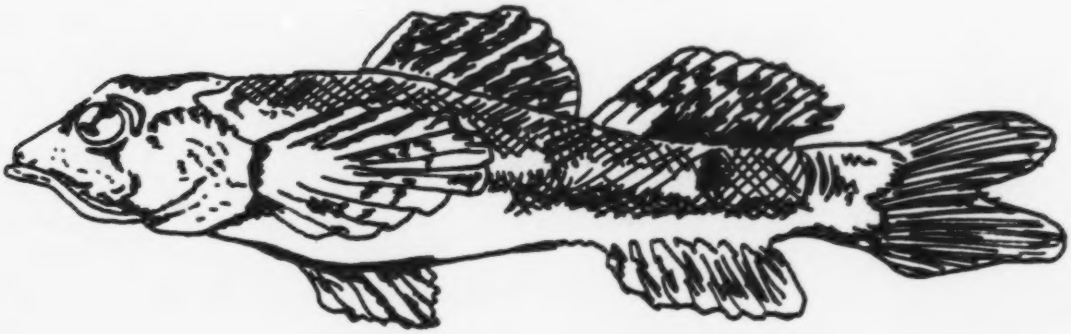
When the dam was about half built, something unexpected happened. A biologist from the University of Tennessee named David Etnier was doing some research in the Little Tennessee River. He was snorkeling there when a small fish that he had never seen before darted out from under a rock and gulped a snail. Later he figured out that the tan, 3-inch-long fish was a Snail Darter. This fish species used to live throughout the eastern Tennessee rivers, but so many dams have been built in the region that this short stretch of the Little Tennessee is now the only place the Snail Darter can live. It is found nowhere else in the world. It needs the cool, clean, flowing water of a big river to survive because it lays its eggs in the shallow, cobbled edges of the river.

Now wouldn't you know it, the only place that the Snail Darter can live is smack above where they are building the Tellico Dam, in the area that would be flooded by the reservoir. The biologists say that if the dam is completed, it would completely destroy the habitat of the little fish. With its habitat destroyed, the Snail Darter would become extinct.

Congress recently passed a new law called the Endangered Species Act to protect plants and animals that are in danger of going extinct. Many people around the country are saying that the dam should be stopped because it threatens the existence of the little fish. They say they will use this Endangered Species Act to protect the Snail Darter and stop the dam.

Meanwhile, the TVA has been trying to build the dam as fast as it can. The dam is now almost 80 percent complete and has already cost over 100 million dollars. Some people say it seems silly to have a little 3-inch fish stop construction of a dam the taxpayers have already paid over 100 million dollars for. As they see it, this little Snail Darter is really good for nothing. You can't eat it for supper or use if for bait. They say the Endangered Species Act wasn't meant to stop nearly finished projects that people need, just to save a plant or animal.

People all over the country have taken sides in this conflict. How do you think this strange story about the little fish versus the big dam should end? Do you think people should let a "good for nothing" fish that can fit in the palm of your hand stop the giant dam project? Explain your position.



Watershed Discussion Questions:

- What if in obtaining water from a certain place, other people's homes were affected? How might this fact change your response?
- How does New York City's water supply change the lives of the Catskill communities?

Source: Adapted from *Whose Right? A Case Study* in Water Wisdom

From Wells to Watersheds

The History of New York City's Water Supply

The city is not an ecological monstrosity.
"It is rather the place where both the problems and the opportunities
of modern technological civilization are most potent and visible." - *Peter Self*

The Growth of a City

In the early 1600s, the Dutch founded what is now New York City and settled on the southern tip of Manhattan Island. During the next 175 years, they depended on wells, ponds, and springs for their fresh water supply as the city began to grow. The main source of water was the Kalch-Hook or The Collect, a 48-acre spring-fed pond located near Franklin and Pearl Streets in lower Manhattan. From here, city-dwellers were able to collect water to bring to their homes for private use. In 1667, shortly after the British seized the city, the first public well was dug inside Fort James on the tip of the island at Bowling Green, located near Battery Park. The well used a pump to bring the water from underground and became the first well of its kind used within the city limits.

The first water distribution system in the city was actually not a series of pipes. It was a group of private carters called Tea Water Men who peddled water from the Tea Water Spring which was located just west of what is now Chinatown.

As the City's population grew, soon the existing wells, springs, and ponds were unable to provide enough water. With no system for disposing of sewage and garbage, human wastes and trash began to pollute the groundwater supplies compromising the quality of this diminishing resource as well. In addition to human contamination, the stone-lined wells dug on the island were becoming tainted by the salt water from the Hudson and East Rivers. In the early 1700s, fresh groundwater was hauled in from Brooklyn which had an excellent supply, though it was not enough to meet the city's increasing demands. In the decades to come, it was this inadequate quantity and quality of the water supply which created catastrophic disasters for the growing city. In 1776, fires burned out of control destroying a quarter of the city's buildings. Epidemics ran rampant with the dirty water contributing to a yellow fever epidemic in 1798 which killed two thousand citizens and a cholera epidemic in 1832 that took 3,500 of the city's people. By the year 1798, one of the city's newspapers described The Collect as "shocking vile where all impure things center together and engender the worst unwholesome productions."

By the late 1700s, the city leaders realized that they needed to develop a cleaner and more abundant source of water for their citizens. The first municipal waterworks within the city limits came at the eve of the Revolutionary War. Between 1774 and 1776, a well and reservoir project was developed to supply water to the city's population of 25,000. The well water was pumped by a steam engine into a reservoir at the location of the present-day Pearl Street and Broadway intersection. The distribution system for this project consisted of bored log pipes. Though it was abandoned due to the revolution, similar services did appear after 1800.

In 1977, the Manhattan Company, which later became the Chase Manhattan Bank, received the right from the New York State legislature to supply New York City with a more abundant water supply. The company built a reservoir at chambers Street and distributed the waterthrough wooden pipes. The devised system proved to be unable to deliver the quality and quantity of water supplies for the growing population.

Construction of the Old Croton System

In 1830, the city's population had reached 200,000 and the demand for an abundant source of clean water was intensifying. The turning point in the city's crusade for a good water supply source was the cholera epidemic in 1832. At that time, State Legislator, Mynert Van Schaick, worked aggressively for the creation of the State Water Commission. In 1832 the Commission, headed by the ex-Mayor Stephen Allen, recommended that the city draw water from the Croton River in Westchester and Putnam counties. The Hudson, Passaic, and Bronx Rivers were also considered but it was the Croton and its major tributaries located 40 miles north of the city which was to be harnessed for the city's new fresh water supply. In the next year, the choice was ratified by popular vote and the city began what was then considered "the most expensive and costly work in America for supplying a city with water." With no immediate precedent to refer to, the aqueduct quickly became unlike anything ever built in America.

Construction of the Old Croton aqueduct began in 1837 and was completed in 1842, delivering water to the Yorkville Reservoir in Central Park, which is now the site of the Great Lawn. The Yorkville was a balancing reservoir. From there the water continued on to the Murray Hill distribution reservoir on the site of the present-day Public Library at Fifth Avenue and 42nd Street in Manhattan. With the addition of a major diverting dam on the Croton River, miles of aqueduct, and additional holding and distribution reservoirs, the Croton System was soon considered one of the great engineering achievements of the nineteenth century. The construction period for this system spanned the next 70 years and marked a significant time of growth for New York City as well as the United States.

In 1898, the municipal consolidation of the boroughs of New York City added a new sense of urgency to the worsening water problem. The city increased its population by over 1 1/4 million people between 1900 and 1910. The United States, at the time the Croton System began, was vast and sparsely populated. When the system was finished decades later, the United States had become a major industrial power, and most of our country's frontier was gone.

Looking Toward the Catskill Mountains

With the years of large scale immigration at the turn of the century, the city's population increased dramatically to over 4 million residents. The city needed to find additional sources of clean and abundant water supplies to keep up with this growth. In 1905, the Legislature passed a measure creating a new Board of Water Supply (BWS) with broad powers to plan and build new reservoirs and aqueducts capturing the resources of the Catskill Mountain watersheds. As a result, construction of the Catskill Aqueduct began in 1907. Completed in 1915, the Catskill System consisted of the Ashokan, Kensico, Hillview and Silver Lake Reservoirs (completed in 1917) plus 126 miles of aqueduct including 18 miles of City Tunnel One which burrowed through solid rock 200 to 750 feet under the Harlem and East Rivers through the Bronx, Manhattan and Queens. This aqueduct was twice as long as the two Croton aqueducts put together end to end. The Catskill System was completed with the addition of the Schoharie Reservoir completed in 1926, bringing the system's full capacity to 470 million gallons of dependable yield water a day.

The construction of the Catskill System was an engineering achievement rivaling the construction of the Panama Canal and was considered to be the greatest municipal water supply in the world. The Ashokan Reservoir alone was built to hold as much water as all ten of the Croton System's reservoirs and the Kensico Reservoir combined. In addition, City Tunnel #1 which crosses under both the Hudson River and the Narrows was considered to be a brilliant unprecedented accomplishment.

Thousands of immigrant workers were recruited by contractors as they stepped ashore into this country. With an incoming work force between 500 and 17,243 workers, the placid rural towns of the Catskills soon found themselves overwhelmed. The local law enforcement agencies, unable to handle the situation, prompted the city to provide a separate police force to keep order in the region. Looking back, it is easy to become awe-struck by how much was accomplished by these work forces in such a short amount of time. Yet it is important to note that all of these projects were not universally approved of.

In order to develop the Catskill Supply System, the city had to displace hundreds of people whose families had for generations lived on land that would is now at the bottom of a reservoir. In doing so, the city was said to have often acted in a manner that was perceived as callous and high-handed by the local residents. The memories of the city's methods in displacing these communities and the residue of ill will are to this day a major obstacle that is met when the city officials and Catskill community members try to work together regarding the watershed waters.

Members of New York City's first reservoir area police force (*photo obtained from NYC's DEP*)

The Delaware System - Capturing Interstate Waters

As New York City's search for fresh and abundant water supplies continued, the Board of Water Supply once again looked toward the Catskill watersheds. The Delaware Reservoir system, the newest and largest of the city's three water supply systems was developed between 1936 and 1965. This immense system was designed to collect waters from the Catskill tributaries and branches of the Delaware River. The Cannonsville, Pepacton, Neversink, and Rondout Reservoirs together feed the Delaware Aqueduct which transports the cleanest of the Catskill waters south to the growing city.

In constructing the additional reservoirs, the city once again displaced hundreds of people and several communities in order to make room for the reservoirs and their buffer lands. The community of Neversink, for example, at this time was a small hamlet with a post office, a church, three stores, a hotel, and a number of farms. Using purchasing powers as well as condemnation notices, the city moved the citizens of Neversink to higher ground, clearing the area for the Neversink Reservoir. Similar situations and conflicts arose with the areas involving the other reservoirs and the communities established within the targeted boundaries. The Pepacton Reservoir, for example, displaced four villages - Pepacton, Shavertown, Union Grove, and Arena.

Developing this system also posed a new problem for the Board of Water Supply. In constructing it, they would be impounding interstate waters for the first time. Downstream states and communities in New Jersey, Pennsylvania, and Delaware fought the implementation of these diversions, challenging the city's plans all the way to the Supreme Court in 1931. The Court issued a decree apportioning the waters of the Delaware River, assuring that a specified minimum allotment of waters would continue down the Delaware River supplying Philadelphia's drinking water systems as well as guaranteeing the necessary balance of salinity downstream in the Delaware Bay for the oyster-fishing industries. In 1954 when the Delaware system was expanded, a similar lawsuit resulted in an amendment to the original decision and reapportioned the Delaware River waters. To this day, the New York City System operates under the terms of that decree.

An added dimension to this stipulation was the establishment of the Delaware River Basin Commission in 1961. Under the terms of this compact, the commission members, being New York, New Jersey, Pennsylvania, Delaware, and the U.S. Department of Interior, could by unanimous vote supersede the provisions of the 1954 Supreme Court decision if a water emergency should arise. During the drought of 1967, just such a situation did come to pass. At the height of the drought, it became obvious if the city were to adhere to the court's decree, it would empty the Delaware System's reservoirs and put the city, as well as downstream communities, at dire risk. A vote of the commission then declared an emergency and modified the provisions of the decree, reducing the amounts released downstream and enabling the supply to be stretched out in order to get everyone through the drought. In learning from this drought as well as several less severe droughts in the 1980s, the supply system was adapted and is now thought to be much better prepared for such a water quantity crisis in the future.

New York City's Water Supply System Today

Throughout its history, New York City has sought to provide a reliable source of water for its citizens and participating communities in the watershed and Westchester counties. Today, these amazing systems of reservoirs, lakes, aqueducts, and water mains distribute approximately 1.4 billion gallons of water a day to over 9 million people including one million upstate residents. That amount totals to over 500 billion gallons a year! Looking back at the development of New York City, it is obvious that without the implementation of these immense watershed systems, the city would not have been able to grow and develop into a great urban center that it has become. In learning more about this amazing system, students in the City and upstate Catskill communities will feel the connection both past and present that they have with individuals as far as one hundred miles away.

New York City's Tunnel #3 under construction (*photo obtained from NYC's DEP*)

Sources: Information obtained from the following: *New York City Water Supply System Fact Sheet* and *Celebrating 150 Years of Clean Drinking Water* both NYC DEP publications, *Croton Supply: Uncommon Purity* and *The Catskill System: From the Mountains to the Boroughs* by Paul J. Sehgal and *New York City Water Supply Past, Present and Future* by Edward Schaeder in Clearwaters, Winter 1992-93 edition, Water-Watchers: A Citizens Guide to New York City Water Supply, and the offices of NYC's DEP.

New York Upstaters and Downstaters

Grades: all grades
Objective: to explore the sources, effects, and validity of New York stereotypes
Subjects: History, Economics, Government, Social Studies

Materials: A black board and chalk, at least four blocks or building toys

Information:

New York - "Say those words anywhere in the world and people think New York City. The City That Never Sleeps. Subways. Crime. The Yankees. Yankee Fans."
- *Joel Stashenko, Associated Press Writer,* The Sunday Record, Feb. 19, 1995

Whether we realize it or not, we all have preconceived ideas about the world around us. These ideas form our attitudes and lead to our perceptions of the characteristics and qualities of the people in other groups. At times, our attitudes and lack of information can cause us to form stereotypes, or false generalizations about people and their cultures. This action is exemplified in the attitudes of some of the people of New York State.

Generally, when people think of New York, they think of the City, even though nearly 8 million people live in the portion of New York State north of the Big Apple. There are four major metropolitan areas upstate plus 2 Great Lakes, 53 counties, 51 daily newspapers, 817 hazardous waste sites, and 1.5 million cows. Yet some say that many New Yorkers feel that all that the upstate and downstate people have in common is the state flag, a postal abbreviation and a governor (*Joel Stashenko*).

Historically and culturally, New York State tends to be divided between the "upstaters" and "downstaters". Though these areas exhibit broad differences politically, economically, demographically, and ethnically, they are linked by more than their state symbols. Rural New York State communities depend upon the City economically through the agricultural, recreational and industrial business transactions they have shared for centuries. New York City depends upon the upstate communities for a large variety of reasons one of which is their drinking water supply from the rural Catskill Watersheds.

Though their interdependence is long established and substantial, these upstaters and downstaters still have many stereotypes and perceptions of each other that take their geographic separations and turn them into communication and cooperation rifts. The following activity takes a closer look at some examples of some New Yorkers' generalizations and discusses their sources, effects and validity.

Procedures:

1. While taking part in either New York social studies or communication and cooperation activities, discuss with the class the cultural differences of many communities. New York has excellent examples of these since it has such a wide variety of communities and populations all within its state borders. Discuss with the students the origins of stereotypes and false generalizations. Explain to them that they will be taking a closer look at the way New York State citizens view each other.

2. Begin with two students standing in the front of the class, close together and facing each other. Ask them to perform a task together such as stacking blocks. Write the following statements in view of the entire class.

New York Stereotypes

- New York City people are always in a hurry.
- All New York City people are fashion-conscious
- All New York City people waste their water supplies.
- All New York City people are rude and impersonal.
- New York City is a dangerous place to live because of all of the crime.
- New York City is nothing but pavement and buildings.
- All New York Upstate people are farmers and hicks.
- All New York Upstate people wear overalls and work boots everyday.
- All New York Upstate people pollute their area's water supplies.
- All New York Upstate people are uneducated.
- Upstate New York is a dangerous place to live because of all of the wild animals.
- Upstate New York is nothing but farm fields and wilderness.

3. Next, encourage the students to find a false generalization that they have heard before. (*Note: It is important that the students understand that they do not have to agree with any of these stereotypes.) When someone identifies a generalization, instruct that student to approach the couple in the front of the class and stand between them. While saying the statement aloud, instruct the additional student to stand between the couple separating them with his/her arms out to the side. The starting couple should then separate making room for the new student. Continue this procedure with new students, statements and a widening of the separation between the original couple.

4. After some distance has been created between the original couple, give the class an opportunity to observe what has just happened. Ask the couple to perform their task again. This should be difficult considering their distance. The original couple illustrates a pair of New York City and Upstate individuals. Point out to the class that the false generalizations mentioned not only separated the couple but they also created a barrier between them. Take this opportunity to discuss with the group how stereotypes cloud peoples' impressions of each other and block efforts in cooperation.

5. Next, break down the barrier by examining each of the false generalizations. Encourage the remaining seated students in the class to locate one of the generalizations and explain why it is false and how people may have come to believe a statement like that. Once that stereotype is invalidated, the barrier student may then be seated and the separation can decrease. In understanding each of these false impressions one by one, students will then be able to visualize how individuals are better able to come together.

Watershed Discussion Questions:

- Why is it important that New York City and Upstate community people work together?
- How can people get around these stereotypes in order to cooperate?

Water Rights Rivalries

Grades: middle and upper

Objectives:

- to become familiar with the history of New York City's Water Supply System
- to weigh the historic social, environmental, and economic factors involved in the implementation of the Delaware and Catskill Reservoir Systems
- to make value judgments regarding the land use management techniques used in the Catskills past and present

Subjects: Earth and Life Sciences, History, Health, Economics, Social Studies, Government

Materials: *Water Rights Rivalries* Topics copied for student use, library resources

Information:

The rural communities of the Catskill Mountains and the large metropolis of New York City are connected in many ways. More than simply sharing water supplies, these communities share a history that provides a great deal of insight into their sometimes rivalrous relationship. It is interesting to note that the Latin root of the English word "rivalry" is *rivus*, meaning a brook. *Rivalis* is someone living near or using the same stream as another person.

The history of New York City's involvement in the Catskill Watersheds goes back to the early 1900s when the rapidly increasing population of the Big Apple dictated the lives and livelihoods of the people of the Delaware and Catskill Watersheds. Looking back at that time in our shared history, it would be unjust to make value judgments by simply observing one side of these controversial clashes. To fully understand the reasoning behind the decisions that were made at the time of the development of these Watershed Systems, one must review all of the dimensions involved including the political, social, economic, and environmental aspects.

The following debate topics are an excellent accompaniment to a history lesson on the development of New York City or Catskill communities. In working through this activity, the students will be encouraged to investigate and analyze the various historic points of view involved in the implementation of New York City's water supply system in the Catskills.

Procedures:

1. After a review of New York City's historic and sometimes rivalrous relationship with several of the rural Catskill communities, encourage the students to research that time period in the early to mid 1900s when New York City's Board of Water Supply developed the Catskill and Delaware Watershed Systems. Additional references on this topic are available in this guide's bibliography. To help the class focus their research on the specifics of the topics, organize a class debate. By enabling the students to defend or oppose sides of these legendary arguments, they will be taking a closer look at this time in history.

3. After the students have a general understanding of the history of the regions, divide the class into four equal working groups. Give each group a different debate issue on the various topics to defend. Supply the groups with ample time and resources to research their topics and formulate a statement or argument.

4. When the groups are ready, gather the class together to present each of the debate issues. Each debate and presentation should have equal time and opportunity to defend or oppose the topic they have researched. Take time in the class to view all of the debates, investigating all of the aspects of this complex issue.

Historic Issues for Watershed Debate Topics

Building a Reservoir: City Officials versus Catskill Community Members

There is currently a proposal to build a reservoir in order to collect the waters from the Neversink Rivers and their tributaries. This water is thought to be the cleanest in the Catskills and also abundant enough to supplement the water supply needed to alleviate the water shortage problems for New York City. The reservoir is targeted to use the land currently inhabited by the hamlet of Neversink, NY. This town has a post office, a church, three stores, a hotel, and several farms. Tough the City will pay taxes on the property, all of these people, as well as the town itself, will need to be moved in order to make room for the reservoir. (Catskill communities, use the example of the reservoir nearest you.)

A. On one side are the citizens of Neversink who realize that this reservoir will result in the farms and other community businesses and homes losing their land that has been in their families for generations.

B. On the other side are the city officials who are responsible for the City's welfare. They realize that the population of 4 million people in the city are heading for disaster if the water supply is not increased by building this water system.

Impounding Interstate Waters: NYC versus Neighboring States

There is currently a proposal to build a reservoir in order to collect the waters from the Neversink Rivers and their tributaries. This water contributes directly to the Delaware River. Diverting these waters will affect the communities downstream in other states.

A. On one side are the citizens of communities in New Jersey, Pennsylvania, and Delaware. Unless a specified amount of water is allowed to continue down the Delaware River from the Catskills, drinking water systems in cities like Philadelphia will be at dire risk as well as the oyster-fishing industries in the Delaware Bay. If a proper amount of water from the Delaware River does not contribute to the Bay, the necessary salinity of the fisheries will be destroyed.

B. On the other side are the city officials who are responsible for the City's welfare. They realize that the population of 4 million people in the city are heading for disaster if the water supply is not increased by building this water system.

5. At the conclusion of the last debate, discuss with the class their personal feelings on the issue of the land use in the Catskill Mountain watersheds during this time in history. Continue the discussion to include their thoughts on how these past interactions help and/or hinder the present communications between the communities today.

Variations:

- To further explore the issues, participate in the *From Wells to Watersheds* history program at the Frost Valley YMCA. By playing out the roles of historical characters, this "living history" lesson helps students to understand and truly appreciate the reality of the situation as well as experience a better insight into this controversial time in the community's history and our common future.
- Research a village or community that was flooded by one of the reservoirs and study who lived there. What was the community like? How did the community cope with NYC's proposal?

Watershed Discussion Questions:

- What happened to the town of Neversink when the reservoir project continued?
- What would have happened to NYC if they had not secured a new source of water?

The Watershed Whodunit

Grades: middle and upper
Objectives: to learn how to use contour mapping in order to detect groundwater flow and investigate the source of groundwater contamination
Subjects: Earth and Life Sciences, Chemistry, Economics, Health, and Social Studies

Materials: copies of the *Watershed Who-dun-it* maps, pencils, pens, rubber bands, scissors, and rulers

Information:

"We have not yet virtually eliminated, nor achieved zero discharge of any persistent toxic substance." - *The International Joint Commission Sixth Biennial Report*

When it comes to water pollution, every little bit hurts. The eight most common types of water pollutants are known to be:

- Disease-causing agents which include bacteria, viruses, protozoa, and parasitic worms that enter the water from domestic sewage and animal wastes;

- Oxygen-demanding wastes which are the organic wastes that can be decomposed by aerobic (oxygen-requiring) bacteria. Large populations of these bacteria supported by wastes can deplete an aquatic environment of necessary dissolved oxygen;

- Water-soluble inorganic chemicals which consist of acids, salts, and compounds of toxic metals like lead and mercury;

- Inorganic plant nutrients which are water-soluble nitrates and phosphates that can cause excessive algae and other aquatic plant growth thus disrupting the ecological balance of an aquatic environment;

- Organic chemicals which include oil, gasoline, plastics, pesticides, cleaning solvents, detergents, and many other chemicals that threaten human and aquatic lifeforms;

- Radioactive isotopes which are water soluble or capable of being biologically amplified to higher concentrations as they travel through food chains and webs;

- Heat which is absorbed by the water that is used to cool electric power plants thus raising the temperature of the water, lowering its dissolved oxygen capacity, and negatively affecting aquatic environments.

The following map-making activity will walk students through the step-by-step process of making a contour map of an area. With this information, the students will then be able to trace a site of water contamination back to its source.

Procedures:

1. Following activities on the topics of water, soils, groundwater supplies, and community development, this activity helps students to use the information they have learned on these subjects to solve a watershed who-dun-it. Begin by reading to the group the description of the town of Watershedville and giving each student a town map.

Welcome to Watershedville, New York

Watershedville is a fictional town with a real problem. Each week, more citizens are complaining that their drinking water tastes bad. In a very small town like this one, there is no central water supply. Every home and most businesses have private wells. The town's mayor tested the water from several wells and found that the groundwater has been contaminated with some kind of fuel. The wells that have been contaminated are marked out on the map of the town. The mayor and other authorities of the town have serveral concerns about this contamination. First, they are concerned about the public health of their citizens and their vital water supply. And second, they are also concerned that the contamination is located in one of New York City's drinking water supply watersheds.

The mayor thinks that the Heating Oil Company is responsible for this contamination and wants them to start investigating their fuel storage tanks which are buried underground to check for leaks. The Heating Oil Company says that they just tested their tanks and know that they are safe. They think that the Trucking Company is the source of the pollution. The Trucking Company says that the source could just as likely be the Heating Oil Company or the Gas Station, since all three places have underground tanks for storing the same kind of fuel.

So Watershedville has a problem and no one is sure who is responsible. The mayor needs some way of proving who is causing the pollution and who should clean it up. You will be the "outside consultant" who helps to prove where the pollutant is coming from. Cleaning up the groundwater supply contamination is a very expensive job. You should be very sure of the place you choose to start cleaning up, otherwise the money will be wasted and the unsolved groundwater mystery may lead to contamination of the surface waters in the watershed before you know it.

2. Next, instruct the students that in order to find which of the suspected businesses is the most likely source of the contamination of the groundwater, the best thing for them to do is to find out the direction that the underground water is flowing. Since groundwater generally flows downhill, following the slope of the surface of the land, they can be fairly certain that the suspected source of the pollutant is the farthest "upstream" of the contamination plume.

3. In order for the students to identify the topography of the town, they will need to create a contour map of the area. Since Watershedville is a very small town, only a few residents know the exact elevation above sea level for their property. To make a contour map, it is helpful to know as many elevations as possible for the region. By following these simple cartography procedures, the students can create an accurate map even though they only know a few of the elevations. Give each student a pen, pencil, rubberband, scissors and ruler to work on their town maps. Instruct them to carefully follow the map-making instructions.

A. Begin at a well with a known elevation. Using the ruler and pencil, lighty draw a line from this well to the nearest wells having at least a 20-foot difference in elevation.

B. Cut a rubberband open and without stretching it lay it out flat along the edge of a ruler. With a pen, make at least five marks 1/2 inch apart beginning from the middle of the band. Use the marked rubberband to help you on curved lines, divide each of the lightly drawn lines into equal 1/2 inch segments.

C. Label each mark on the line between the known elevations with the estimated elevations. For example, if the elevations at each well are 10 and 40 feet above sea level, you should make two marks on the line, dividing the line into three equal lengths. The first new mark should be labeled 20 feet and the next one labeled 30 feet.

D. Connect all of marks having the same elevation with a smooth contour line.

E. Every half inch or so along each contour line, draw a short arrow perpendicular from the line out towards the line having the next lowest elevation. The groundwater is flowing in the direction of the arrows.

F. Find all of the contaminated wells and if possible, draw a single loop that contains only these wells and none of the uncontaminated wells. The area inside this loop shows how far the contamination has already spread through the groundwater. This is called the contamination plume.

4. After the students have completed their investigations, discuss their findings. Some questions to ask may be: If the flow of the groundwater and the pollutants in it follow the flow direction, what is the most likely source of the contamination? Which uncontaminated wells do you expect will become contaminated in the future? How do you explain that one well within the plume was not contaminated? How would the map look if all three of the companies' storage tanks were leaking?

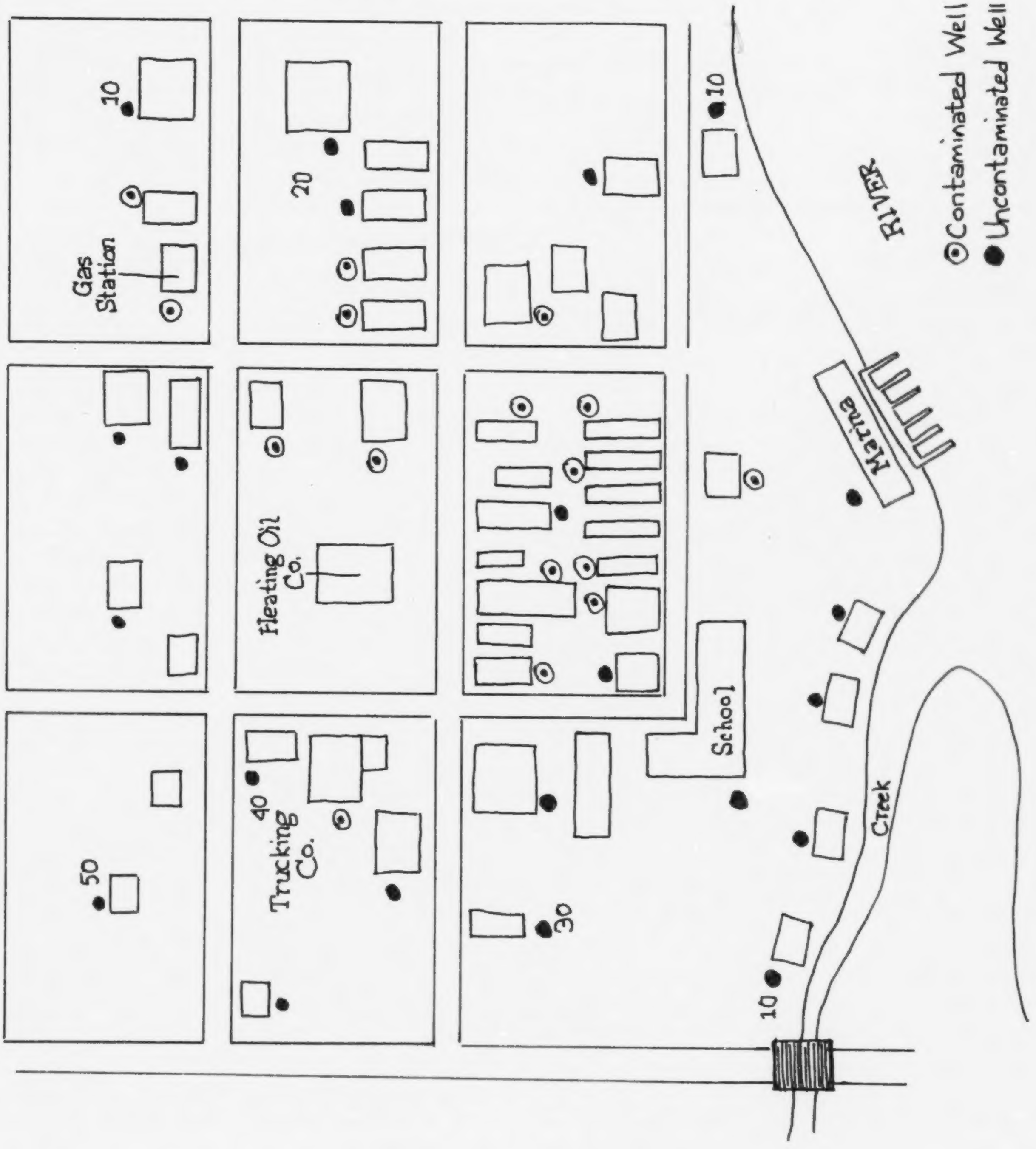
Variation:

- Obtain a topographic (USGS) map of your own community and use it to chart out the ground and surface water directions. Locate your community's water supply and any potential sources of contamination. (*Note: If your community is underlain by limestone or dolomite, this methodology will probably produce incorrect results. Groundwater flow in limestone or karst terrains rarely is restricted by topographic boundaries.)

Watershed Discussion Questions:

- What kind of precautions should be taken to keep an eye on potential sources of contamination of your drinking water supply?
- How do the Catskill Mountain communities insure that the waters contributing to NYC's supply are not contaminated? (See *Catskill Communtiy Solutions to Water Pollution*)
- What are some examples of "natural" water pollutants that may affect the quality of a drinking water supply? (i.e. sedimentation and acid deposition)

Source: Adapted from *Tracking Pollution - A Hazardous Whodunnit* in Student Activity Sheets for Drinking Water Projects


Gas Station
10
20
Heating Oil Co.
Trucking Co.
40
50
30
School
Marina
10
RIVER
Creek
10
⊙ Contaminated Well
● Uncontaminated Well

The Development Within the Watersheds
Assessment Tools

Persuasive Writing Exercises

"I hold that what can not be accomplished by reasoning and by discretion and skill is never accomplished by force. I was thus brought up."
- Michel De Montaigne

As students begin to learn about the dynamic topics involved in community development within the watersheds, it is necessary that we, as educators, do not stop short of presenting the entire picture including all of the aspects of a particular issue. By presenting one side of a situation alone, we may encourage students to draw their conclusions from incomplete and thus biased information. Persuasive Writing Exercises can serve as assessments of not only the student's comprehension of the subject material but also as a gauge of the students' ability to absorb all of the dimensions of an issue. This type of writing exercise can be additionally beneficial if students are encouraged to write a persuasive writing for the opposite view of their own. After all, it was Margaret Thatcher who once said, "It pays to know the enemy - not least because at some time you may have the opportunity to turn him into a friend".

The following are some suggested statements and subjects for persuasive writing exercises that aim to increase your students' understanding of topics focusing on New York State's Water, Watersheds and People.

Historic New York City and the Catskill Watersheds:

New York City officials did not have the right in the early 1900s to displace the rural Catskill communities in order to build their reservoir system.
New York City officials did have the right because . . .

New York City officials had the right in the 1900s to impound interstate waters in order to build their reservoir system for the growing population.
New York City officials did not have the right in the 1900s to divert the Delaware River's waters in order to build their reservoir system because it affected states and communities downstream.

Current New York City Water Issues:

NYC should continue to meter its water uses to identify water consumption rates.
NYC does not need to meter its water uses. There is no reason for the expense of this system.

New York City should charge for its water in order to promote conservation.
New York City should not charge for its water supplies because. . .

New York City should build a filtration plant to insure its water's quality.
New York City does not need to build a filtration plant because they exercise excellent land use management techniques in the Catskill/Delaware Watersheds.

The Development Within the Watersheds

Class Follow-up Projects

If after studying this section on Development Within the Watersheds the class is eager to build on these lessons, here are some ideas for some successful follow-up activities and interesting class enhancements involving in-depth looks at these social, economic and environmental concerns.

Your Community's History:

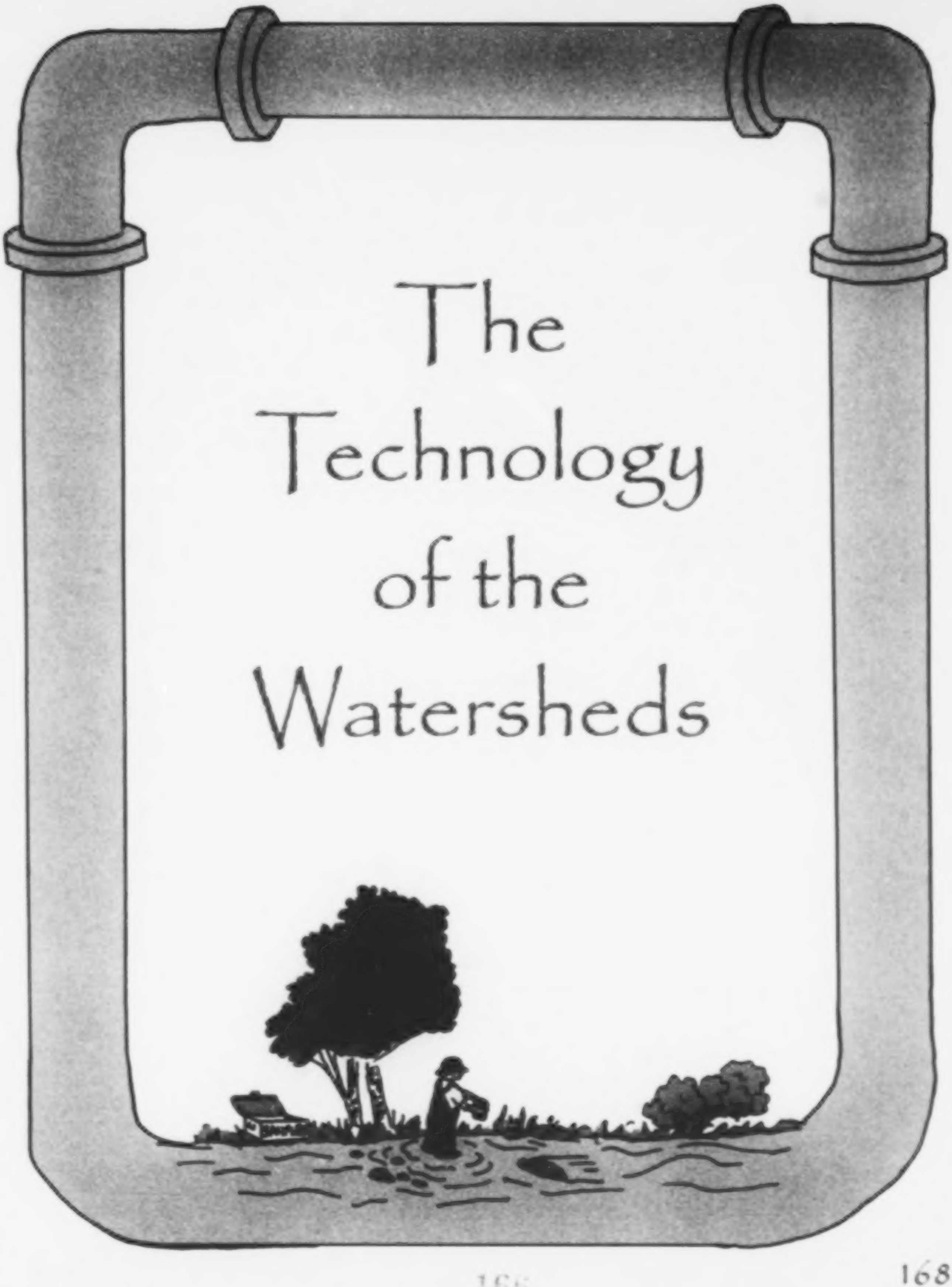
- **Looking back from whence we came** - This activity is not only fun but it also promotes a sense of local pride in the students by having the class research the history of their neighborhood or community. Using this information, work with the students to create a play depicting the development of the section of New York State they call home.
- **What would they think?** - As the students look back at the history of their area, it is fun for the class to take a serious look at what future historians may think as they look back at our present-day life-styles. Encourage the students to discuss and write about a case when a future archeologist may misinterpret something they left behind. Or talk about what clues we are leaving that will enable future generations to understand us and our lives and life-styles. Continue this thought process with the activity "What is it?", a game in which you present a small object and the class tries to think of as many different uses and names for the objects as they can.

Guess Who's Coming to Class:

A great opportunity for students to learn more about a community topic is to meet a local professional and learn about his/her job and responsibilities. If planned consciously, inviting professionals to visit the class can also provide great career incentives and role models especially if you provide a variety of individuals mixing gender and ethnic groups as well as people with physical disabilities. Some suggested agencies on the subject of community water supplies are representatives from:

- NYC Department of Environmental Protection
- The Frost Valley YMCA's Environmental Education Outreach Program
- Your Local Wastewater Treatment Plant
- Your Local Historian
- NYC's Government/Catskill Community's Government
- Watershed Agricultural Council of New York City's Watersheds
- Your Local Cooperative Extension Offices
- Water Research Scientists (United States Geological Survey)
- A Catskill Fishery
- New York State Department of Environmental Conservation

The Technology of the Watersheds



The Technology of the Watersheds

This section of our guide includes the following:

- information inserts - 🚰 - on the subject of New York City's water supply system
- a variety of activities exploring topics in the quantities and qualities of the waters delivered to New York City and how these dynamics affect the ways of the watersheds

🚰 *Harnessing the Headwaters*

The Scope of New York City's Water Supply System

Delivering a Drop - A Guided Imagery Activity

to illustrate the path water from the Catskills takes through New York City's Waterworks

How Big Is Big?

Comparing Capacities
Calculating Capacities
to illustrate the water capacities of the reservoirs in NYC's water supply system

Gallons Per Minute

to calculate the quantity of water flowing in a stream at a given time

🚰 *Monitoring the Quality of the Quantities*

NYC's Department of Environmental Protection's Water Quality Laboratories

Is It Clean?

to explore the quality of seemingly clean water

Water Carry

to increase students' awareness of how people in developing areas of the world obtain safe drinking water

Assessment Tools

Class Follow-up Projects

Harnessing the Headwaters

The Scope of New York City's Water Supply Systems

> "For most of us, the water supply systems that serve New York City are simply their most visible parts — the fixtures at the end of the line. Or so it seems, until the flood from a broken water main reminds us of the great rivers of water that surge beneath us, or until drought draws our attention to the distant mountain regions from which most of that water comes. Only then do we sense the vast scale of the supply systems we depend on. Only then do we sense their grandeur and their vulnerability."
> - Water-Watchers: A Citizens Guide to New York City Water Supply

The Croton Supply

The oldest of the three reservoir systems, the Croton draws waters from surface sources in the drainage area of the Croton River, a Hudson River tributary in Westchester and Putnam counties. The water delivered by these structures travels through systems developed in the 19th and early 20th centuries.

As we look back at the history of New York City's Water Supply, when the original Croton System was opened in 1842 the new water supply was greeted with "The Great Water Celebration". Cannons boomed, bells rang and fountains roared as the city's citizens joined in a gigantic parade to the City Hall. The water officials could now relax with this system able to supply waters for a population up to 800,000 people which New York City was not predicted to reach for another 30 years. Yet as time continued, so did the growth of the city. The population soared. By the 1880s, there were plans for a new aqueduct, dam and larger watershed. It took only 14 years to reach the system's capacity of 800,000 water-users. Per capita consumption also increased as people had grown accustomed to clean water and continued to require more and more of it. As a result, the Croton System needed to be redesigned.

In order to meet the storage and distribution needs, new reservoirs were added to the system including the addition of the 107-acre Lake Manhatta, today known as the Jacqueline Kennedy Onassis Reservoir located in Central Park. In order to provide more water to the system, new reservoirs were built in the years between 1866 and 1911 by damming the branches and tributaries of the Croton River and tapping into the Bronx and Byram Rivers. The original Croton Dam was completely submerged by the waters held back by the New Croton Dam. The massive masonry dam was considered to be the tallest in the world at that time. The Croton system was also supplemented in 1893 by a new aqueduct that had over three times the capacity of the original. And for the first time, the water was delivered to Manhattan underneath the Harlem River, plunging beneath the river in this 7 1/2 mile pressure tunnel.

The current Croton System consists of 12 water reservoirs and 3 controlled lakes. The largest of the reservoirs, the New Croton, can hold up to 19 billion gallons of water. Unfavorable conditions in the Croton's watersheds make this water less desirable compared with that which drains from the Catskills systems. Runoff from the fertile soils within the Croton's boundaries contribute to the growth of algae and other water plants thus causing a high instance of eutrophication. Additionally, advancing urbanization has brought on water quality concerns with runoff, erosion, sewage discharge and nutrient loading contaminating the waters. The smaller reservoirs in this system do not give nature the time or opportunity to act effectively as a purifying agent. Because of these pollution problems, present and potential, a proposed major water filtration plant must be built for this system in the near future as required by the Federal Safe Drinking Water Act Surface Water Rule. Further studies are underway to substantiate the need for this expense. Due to its size and water quality, this system normally supplies the city with approximately 10% of its water with additional quantities being drawn during periods of drought.

The Catskill Supply

This system was designed just as the Croton was being completed in the first decade of the 1900s. Collecting water from these areas 100 miles north of the city and 35 miles west of the Hudson River, most of which are stored in the giant Ashokan Reservoir (capacity 122.9 billion gallons) with the balance remaining in the Schoharie Reservoir (capacity 17.6 billion gallons).

The Esopus Creek which naturally flows into the Hudson and drains a watershed of about 257 square miles is dammed by the Olive Bridge Dam creating the Ashokan Reservoir. The Schoharie Creek drains into the Mohawk River and collects from an area of approximately 314 square miles. The Gilboa Dam stops the Schoharie Creek waters north of the Esopus and forms the Schoharie Reservoir. The tributaries of this water impoundment which is 1130 feet above sea level have origins at almost 2,200 feet above sea level near the towns of Hunter, Windham, Prattsville and Grand Gorge in the Catskill counties of Greene, Delaware and Schoharie.

Waters from the Schoharie Reservoir continue on through the Shandaken Tunnel to the Ashokan Reservoir where the Catskill Aqueduct begins. This impressive underground aqueduct stretches 92 miles to the Hillview Reservoir in Yonkers, is 17 feet in diameter and has the capacity to transport 501 million gallons a day from the Ashokan Reservoir to the Kenisco Reservoir and on to thirsty city-dwellers. With the two reservoirs completed in 1915 and 1927 respectively, this system now supply New York City with approximately 40% of its daily needs.

The Delaware Supply

The Delaware is not only the newest but it is the largest of the three water systems. Constructed between 1936 and 1965 and supplying the city with approximately 50% of its daily water needs, this system is also known to possess the purest of New York City's waters. Collecting from predominately wilderness and rural watershed regions totaling over 1000 square miles, this system consists of four immense reservoirs (the Cannonsville, Pepacton, Neversink, and Rondout) harnessing waters destined for the Delaware and Hudson Rivers. The Cannonsville Reservoir, completed in 1965, is formed by the Cannonsville Dam on the West Branch of the Delaware River. This water impoundment has a capacity of 95.7 billion gallons of water. The largest of New York City's reservoirs, the Pepacton has a capacity of 140.2 billion gallons and was formed behind the Downsville Dam across the East Branch of the Delaware River in 1954. At 1440 feet above sea level, the Neversink reservoir, completed in 1951, holds 34.9 billion gallons of water and was formed behind the Neversink Dam across the Neversink River, a tributary to the Delaware.

With the waters contributing to the Neversink Reservoir flowing through predominantly wilderness or sparsely-populated areas, the Neversink boasts the most pristine waters of the entire New York City System. Known as the "Champagne of Drinking Water", the Neversink drains the very rivers and streams that run through Frost Valley.

The Neversink, along with the Pepacton and Cannonsville Reservoirs, feed eastward through separate rock tunnels to the Rondout Reservoir where the Delaware Aqueduct begins. The Rondout collects waters destined for the Hudson River from its 95 square mile watershed which would ordinarily continue to the Rondout Creek. An interesting dimension of this system is that the water which flows from the Neversink to the Rondout Reservoir powers turbines that provide electricity to the surrounding communities. Thorughout the water supply system, there are other hydropower facilities such as this one. The waters continuing through this particular system exit the Rondout Reservoir via the Delaware Aqueduct and meet the Catskill waters at the Kenisco Reservoir in Valhalla in Westchester County.

New York City's Pepacton Reservoir (*Photo obtained from NYC's DEP*)

As mentioned in the historical description of this water supply (*From Wells to Watersheds*), the creation of this system for New York City required, for the first time in its history, the impoundment of interstate waters. The Supreme Court decree that ensued requires that the Delaware System to release a minimum of 17,050 cubic foot/sec. of water down the Delaware River from the Neversink Reservoir supplying Philadelphia and other downstream communities with their share of this valuable resource. At a check point on the Delaware River in Montague, New Jersey, the "River Master", a supreme court mandated position, monitors the water flowing daily to insure that the stipulations of the decree are followed.

The Delaware system also has the capacity to pump waters directly from the Hudson if drought situations should arise that warrant this action. Water may be pumped into the Delaware Aqueduct from the standby pump station at Chelsea, New York capable of drawing up to 100 million gallons a day from the Hudson. This station was reconstructed from its original design in 1965-66 during a drought emergency and operated for approximately ten months. It was then placed on standby status until 1981 when another serious drought necessitated placing the station in service and running it for about five months. In the spring of 1989, after a winter with extraordinarily low precipitation in the Catskills, the station drew water from the Hudson for a period of two weeks before the heavy rains finally came.

New York City's Water Systems Working Together

Over one hundred and fifty years ago, water flowed for the first time from upstate collecting systems to eager citizens. The watersheds of the Croton, Catskill and Delaware Systems cover nine different counties and an area of almost 2,000 square miles. That's larger than the State of Delaware. All together, the reservoirs have a storage capacity of approximately 550 billion gallons of water.

In order for the water in the Catskills to reach a faucet in New York City, it must travel through a unique and dynamic system that includes 22 reservoirs and controlled lakes, over 400 miles of immense underground tunnels (some as far as 750 feet below ground level), pass through approximately 5,800 miles of pipes, 184,000 valves and 100,000 hydrants. It is also interesting to note that 96% of this water arrives at the city through the force of gravity alone without pumping or additional pressure.

The following activities will guide students through their investigations of this gigantic water system without having to load into a bus for a field trip. These lessons can then be a wonderful start to sharing in the system that connects Upstate and New York City communities.

Sources: Information obtained from the following: New York City Water Supply System Fact Sheet and Celebrating 150 Years of Clean Drinking Water both NYC DEP publications, *Croton Supply: Uncommon Purity* by Paul J. Sehgal and *New York City Water Supply Past, Present and Future* by Edward Schaeder both appear in Clearwaters, Winter 1992-93 edition, Water-Watchers: A Citizens Guide to New York City Water Supply as well as facts and figures supplied by our colleagues at the NYC DEP offices.

Delivering a Water Drop - Guided Imagery

Grades: elementary and middle
Objective: to illustrate the path water follows from the Catskills to NYC's Waterworks
Subjects: Earth and Life Sciences, Social Studies, History

Materials: A quiet place where the class will not be disturbed, a copy of the *Delivering a Water Drop* Guided Imagery

Information:

"Water flows from high mountains. Water runs deep in the Earth. Miraculously, water comes to us, and sustains all life." - *Thich Nhat Hanh*

Waters from Catskill mountain streams are collected in New York City's giant reservoirs and their aqueducts transport this valuable resource over a hundred miles to the homes, schools, and businesses throughout New York City's five buroughs and many upstate communities. The term "aqueducts" in New York's Water System refers to the huge tunnels or conduits that carry the waters over these great distances. In the system, there are two basic types of aqueducts, the grade aqueducts and the pressure tunnels. Both of these delivery structures rely on gravity to power the water's flow.

A grade aqueduct is a downward sloping tunnel that is only partially filled with water. The waters in grade aqueducts flow downhill much the same as they would in a river. A pressure tunnel, on the other hand, is completely filled with water thus producing pressure in order to push the water through the enclosed aqueduct. With the pressure of the waters pushing from behind, these tunnels can deliver water down deep into the ground and then up again to its original height without the use of a pumping mechanism.

The Catskill Aqueduct is an excellent example of these types of aqueducts working together. For the most part, the Catskill Aqueduct is a grade aqueduct. But in one section of the journey, the aqueduct turns to a pressure tunnel as it plunges 1,100 feet below sea level in order to run underneath the Hudson River. On the other side of the river, the pressure produced in the tunnel provides the needed energy for the water's ascent.

The following guided imagery activity will help students understand the dynamics and distances involved in a drop of water delivered from the Catskills to a faucet in New York City.

Procedures:

1. During a lesson in which the class is discussing the scope of New York City's water supply system, introduce this activity as an opportunity for the students to make the journey that the Catskill waters make without actually leaving the room. Explain the goals behind guided imagery, noting that this activity will give them the freedom to use their imaginations in order to complete the pictures they will need to view the water supply system.
2. Find a quiet place in which the class will not be disturbed and encourage the students to make themselves comfortable. They may wish to lie down, take their shoes off and just relax for the length of this activity. Next, ask the class to close their eyes and listen to the story while they use their daydreams to supply the visions of what the story describes. When the class is ready, read the *Delivering a Water Drop* story out loud to them.
3. At the conclusion of the reading, bring the students mentally back to the classroom and discuss the feelings and impressions they had during the story.

Delivering a Water Drop

This is a story that will take you on a journey from the country to the city, through mountains and underground; spanning distances of over 100 miles in order to deliver a drop of water. As the journey unfolds, imagine that you are taking this trip. Imagine that you are the water drop.

As this story begins, you are floating in a cloud high above the Catskill Mountains. Relax as you drift with the cloud through the open skies looking down on the communities and farms of the Catskills. As you float past the center of the mountains, look down and you can see the Frost Valley YMCA, a temporary home to visiting school groups who are there to learn about the environment. Your cloud is now getting crowded with more and more water molecules. Other droplets are beginning to bump and push into you. The cloud is becoming too full. It cannot hold back any longer. With a sudden burst, you and the other water drops are sent falling to the earth. On your way down, you can see the roofs of the buildings at the YMCA center getting closer and closer.

Tink! You have hit the skylight of the Dining Hall at Frost Valley. As you snake your way across the glass, you can look down and see students and their teachers having pizza for lunch. Your view of the room is short as you continue rolling onto the shingled surface of the roof. Faster and faster, you head toward the edge! Falling again, you land . . . Splash! . . . in a puddle on the path leading into the building.

But wait! You're still moving, flowing downhill. You are being pushed and pulled down the path becoming part of the hill's runoff. Particles of dirt and soil are picked up in the water and are flowing alongside of you. You and the other water drops are now reaching the end of the path and are all entering a grassy area. Dodging and weaving through the grass blades, you make your way through the lawn continuing your downhill journey. The dirt and soil can't make the moves with you so they are settling into the lawn. The grass ends and you are now - dropping again! - Querplunk! You fall into a small stream.

With all of the other rain drops joining you in the stream, the current is running fast. You're shooting down through the rocks and water plants, past frogs, bugs and fishes gaining speed as you move along. The stream is getting wider now and turning into a river. This is the East Branch of the Neversink River. You're moving even faster now. Here comes a sharp turn! Zoom! You shoot past rocks and bridges as the current carries you on.

Bump! You knocked into something! What was that? Looking up you can see a pair of boots standing in the water with a person inside them. Why, he's fishing. As you continue downstream, you can see him casting back and forth trying to get a fish to bite his line. Rounding the next corner, you can see a fish down by a rock looking back at the fisherman and smiling.

Whoosh! The river has opened up now because your river, the West Branch of the Neversink, has met the East Branch of the Neversink . Now you're flowing down the Main Branch of the Neversink River and moving even faster.

Splash! You're riding the river into a large reservoir. There must be billions of gallons of water in here with you. As you float across the Neversink Reservoir you can begin to see an opening in the wall of this giant lake. Floating toward that opening, you can look down and see all of the dirt and soil particles from the raging river settle to the bottom of the reservoir.

The opening is coming closer and closer. This hole is really big! It must be over 8 feet wide and it's lined with cement.

Suddenly, Zoom! you're sucked into the hole which is actually the beginning of a tunnel. This tunnel is huge. It's about 10 feet tall and just as wide. Inside is a large river flowing down into the dark tunnel taking up most of the avialable space. It's really dark now but you are still bumping and pushing downhill with all of the other water drops in the tunnel. Whirl! You rush past the big turbines in the tunnel that use the water's current to turn and produce electricity for the towns above.

Wait! There's light up ahead. Why it's another reservoir. This is the Rondout Reservoir and it is bigger than the Neversink. There's water in here from all over this side of the Catskills and you're all mixing and floating together. Floating and floating, you continue on across this big reservoir. It's 8 1/2 miles to the other side and you continue on. Finally, after two weeks of drifting, you can see the other side. There's another opening over there. This one is even bigger than the last one.

Whoosh! You rush into the tunnel with the rest of the water drops. You're now in the Delaware Aqueduct and it is at least 13 to 19 feet tall and wide. You're now starting a journey down this huge tunnel that will take you over eighty miles. If someone were to put you in a car and drive you on the highway for that many miles, it would take you over an hour and a half to go that far. This trip through the tunnel will take you much longer than that. The officials in charge of this tunnel estimate that it would take you up to 60 days to make the full trip through this system. You can feel the tunnel dipping and turning through the ground and you can sense all of the earth above the tunnel's walls. Wait! You're flowing faster. You can feel that you and the other water drops are moving quicker as the tunnel dives deeper into the ground. When you reach the bottom, you will be 1,100 feet below sea level. Above you, on the other side of the tunnel wall, there is even more water. The tunnel you are in is now running under the big Hudson River.

Space is getting tight now. The tunnel is getting smaller and the underground river is now taking up all of the space in the aqueduct. The waters behind you are pushing hard, lifting you up as this pressure tunnel begins to head up toward the surface on the other side of the river.

Ahh. At the top, the tunnel is larger and you and the other waters can relax and flow downhill continuing your underground journey. Wait! There's another light. It's another reservoir. This one looks small compared to the huge Rondout. Splash! You drop into the Kensico Reservoir in Westchester. What a trip so far. Here you're mixing with water drops from the other side of the Catskills as well as waters from here in the Kensico's watershed. But since this is only a balancing reservoir, it is small. It is time to move on toward the next tunnel.

Whoosh! You're back in the giant Delaware Aqueduct, but not for long. The tunnel dips down underground but before you know it . . . Splash! . . . you're in another reservoir. This one is a distribution reservoir and boy is it small. It feels more like a swimming pool compared to the Catskill reservoirs. Actually the Hillview Reservoir in Yonkers is only a short stay for you because it is designed to distribute you and the other waters to the different areas of New York City.

You're quickly being pushed into another tunnel. This one is tight and the pressure is high with all of the other waters pushing behind you. You're in City Tunnel #1 now and it is big, up to 15 feet across, but you are all packed in there tight. With the pressure behind pushing you forward, you're following the tunnel down under the river and toward Manhattan. Some of the other waters are being diverted toward the Bronx and other boroughs, but you continue forward.

Here comes another opening. Whoosh! You turn into the new tunnel. This one is even smaller! This pipe is only about 20 inches wide. It's a water main. If you listen carefully, you can here the Manhattan traffic above. The pipe you are in is buried four feet beneath the roads. As you are pushed through the pipe, you can see some service connections for buildings and hydrants. Inside this water distribution grid, as the water officials call it, there are about 2.2 million feet of these large trunk mains like the one you are in. There are also about 28.5 million feet of smaller mains, 800,000 service connections and 99,000 hydrants. But you don't have time to count them all.

Quickly, you turn into one of the building service connections and . . . Whir! . . . you're now heading up again being pushed by the miles of water behind you. Wait! You stopped. After miles of streams and rivers, four reservoirs, a huge number of miles in underground aqueducts, water mains and pipes, you have stopped moving. If you listen carefully, you can hear people talking.

"I'm thirsty, Grandma," a young voice says.

"Well, go to the sink and get yourself a glass of water," a tender voice answers. As the young person turns the handle to the faucet, you and the other water drops in the pipe rush out into the small glass. You have arrived in Manhattan. It's been a long journey all the way from a cloud over the Catskills Mountains. But this little person is thirsty and I'm sure, if she knew, she would appreciate the effort it took you to journey so far.

Variations:

- Instead of a guided imagery activity, have your students explore the journey by illustrating the different locations through which the water drop travels in the story.
- Use this story as a beginning reference for older students researching the different steps in the delivery system. Encourage groups of students to find out more about each of the reservoirs and aqueduct facilities in the library and prepare reports or presentations to share with the class.
- Use this activity in any form to introduce the system to the class before a tour by the NYC Department of Environmental Protection of the water supply system facilities. For more information on these tours both in New York City and the Watersheds, contact the New York City DEP Education Office at (718) 595-3506.

Watershed Discussion Questions:

- What are the giant reservoirs in the Catskills used for?
- How does the water in the Catskills get to New York City through the supply system if the City does not use pumps to move the water?
- Why is the amount of rain and snowfall in the Catskills important to NYC residents?

How Big Is Big?

- Calculating and Comparing Reservoir Capacities

Grades: all grade levels
Objective: to illustrate the capacities of the reservoirs in NYC's water supply system
Subjects: Earth Science, Math, Social Studies

Information:

Did you know . . . People are about a billion times larger than the carbon atoms they are made of. Stars are about a billion times bigger than people. And the space between stars, that is a billion times bigger still!

The most visible parts of New York City's water supply system are the reservoirs used for collecting, storing, balancing and distributing the City's vital resource. As the system's aqueducts transport the waters from the collecting reservoirs within the watershed areas, the resources are routed through balancing and distribution reservoirs close to or within the City's limits. The roles of these smaller reservoirs are to regulate the steady inflow of water from the aqueducts and allocate the fluctuating outflows to meet the city's needs.

New York City's balancing reservoirs are designed to meet the daily needs of the population. The distribution reservoirs are made to meet the city's hourly needs for water. By using a combination of collecting, balancing and distribution reservoirs, the entire system is able to insure an adequate amount of water to meet the needs of everyone. For example, the Catskill and Delaware water supplies meet and mix at the Kensico Balancing Reservoir just north of White Plains. The waters then continue on to the distribution reservoirs at Hillview in Yonkers and the Silver Lake Tanks in Staten Island. From the distribution reservoirs, the system continues directly to the tunnels, riser shafts, mains, connections and plumbing lines leading to the water taps and hydrants of the city. The Croton Supply System, being much smaller than the Catskill Systems, runs a bit differently. The New Croton Reservoir is the balancing reservoir for the Croton System. From there, the water continues to the Jerome Park Reservoir which is the primary distribution reservoir for that system. The Central Park Reservoir, now known as the Jacqueline Kennedy Onassis Reservoir, is an additional distribution reservoir for the Croton System but it is only used in the time of a water emergency.

When calculated all together, the reservoirs of New York's system have the storage capacity of 547 billion gallons (roughly one year's worth of water). The following activities will help students comprehend the magnitudes of these volumes while comparing the different water impoundments and also manipulating and quantifying these enormous measurements.

Comparing Capacities

Grades: elementary and middle

Materials: 1 clear 5-gallon bucket, two 1-liter plastic pop bottles, a calibrated jug measuring gallons, eight pieces of paper, a marker and an accessible water tap

Procedures:

1. While discussing with the class the purposes and locations of the different reservoirs in the water supply system, it is interesting to compare their sizes and capacities. Simply listing the reservoirs by name and volumes often does not allow for the students to truly appreciate their differences in size. This demonstration will help younger students compare the volumes with a more visual method enabling them to better picture the contrasting sizes of reservoirs available in the system.

2. Begin the demonstration by gathering together the needed materials. Label the two bottles with the names the Central Park (now known as the Jacqueline Kennedy Onassis Reservoir) and the Hillview Reservoirs. Next, make labels for the bucket entitled the Pepacton, the Neversink, the Rondout, the Ashokan, the Cannonsville and the Croton Reservoirs.

3. Following the capacities chart listing representatives of the system's reservoirs, have the students work together to measure out the capacities for these reservoirs using the graduated cylinder and the water containers. For ease in measuring, we suggest you substitute each billion gallon measurement for one gallon. In that way, you will be able to perform the demonstration without using excessive amounts of water.

The Reservoir	**Storage Capacity in Billions of Gallons**	**Watershed in Sq. Miles**
Jacqueline Kennedy Onassis	1	-
Hillview	.9	-
Neversink	34.9	93
Rondout	49.6	95
The Croton's 10 Reservoirs and 3 Lakes	86.6	332
Cannonsville	95.7	450
Ashokan	122.9	257
Pepacton	140.2	372

5. When measuring the larger reservoirs, the students should fill the bucket with the quantified water and then calculate the amount of buckets needed to finish the measurement noting that amount on the reservoir's label. For example: The Pepacton Reservoir's capacity measured in representative gallons would amount to about 140 filling approximately 28 five-gallon buckets.

6. Finally, line-up the available water containers and labels in order of increasing size of the reservoirs. Compare and discuss the reasoning behind the different sizes of the water impoundments. Is it a matter of space in the location, the size of the watershed or the function of the reservoir that determines its size?

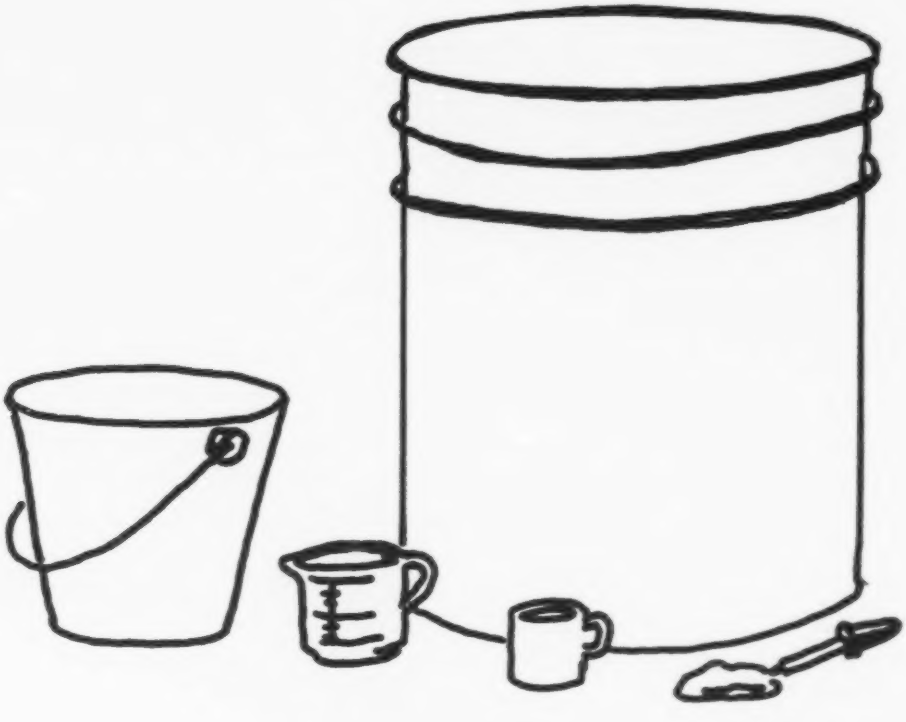
7. Care should be taken in the discussions during this activity to note that these measurements are in actuality much larger than the volumes the class has been measuring. A follow-up activity or discussion for this lesson would be one exploring the actual magnitude of the waters present in these reservoirs. (See the following activity titled: *Calculating Capacities*)

Variations:

- Starting with extremely small and continuing up to larger-sized containers, measure out different receptacles representing each of the reservoir's capacities and have the students match the names and volumes to the correct containers. Note: Do not over-look the classroom's large garbage can for a possibility for the largest of the reservoir capacities. Along the same lines as the different containers, use a series of balls of varying sizes to represent the capacities of the reservoirs. These dramatic differences lead you to using small balls the size of marbles and large balls the size of beach balls.

Watershed Discussion Questions:

- How much land do each of these reservoirs use?
- How do the communities in the areas of the reservoirs use the waters themselves?
- If New York City and some upstate communities use 1.4 billion gallons of water a day, how long would the storage capacity of the system (approximately 550 billion gallons) last if there was not any additional water being added to it daily?



Calculating Capacities

Grades: middle and upper
Materials: Several plastic gallon milk jugs, rulers, paper, pencils, calculators (optional)

Procedures:

1. While discussing with the class the sizes and purposes of the different reservoirs in the water supply system, continue the lesson with this follow-up activity which looks into the actual magnitude of the reservoirs' capacities. Again, simply listing the reservoirs by name and volumes does not allow for the students to truly appreciate the quantities involved in these impoundments. These math exercises will help students comprehend the enormity of the volumes.

2. Begin by discussing the capacities of the reservoirs listed in the preceding activity. Ask the class, "How much space would you need if you had 35 billion gallons of water to store?" That's how much water is in the Neversink Reservoir when it is filled to its capacity. The amount of land the reservoir uses is about 15,000 acres, but the volume of space the reservoir uses is much more than that when you consider the depth of the water body. In order to find out just how much space that amount of water requires, arrange the class in working groups of two or three so that they may work together to calculate the following math equations.

3. Give each group one gallon jug, a ruler, paper and pencil and the following question: How much space would you need if you had 35 billion of these gallon jugs? The following paragraphs outline a simple thought process that will lead the students to the amount they are looking for.

   How much room is used by 35 billion jugs?

   The groups should begin by measuring the volume of the gallon jug with the ruler. A jug that is 6 in. x 5.5 in. x 10 in. would take up 330 cubic inches or .19 cubic feet/gallon in space. [*Note: 330 inches ÷ (12 in/ft x 12 in/ft x 12 in/ft) = .19 cubic feet] To calculate the amount of space used by 35 billion of these containers, the students should then multiply .19 cubic feet/gallon x 35,000,000,000 gallons which gives you an area of 6,650,000,000 cu.ft.

   How many jugs would fit in your school's gym?

   In order to get a better handle on the magnitude of the total area of 6,650,000,000 cubic feet, have the students calculate how many jugs would then fit into their school's gymnasium. This can be done by measuring the volume of the gym and dividing that number by the volume of the one jug. For example, if the room was 100 ft x 100 ft x 20 ft, the total volume of the room would equal 200,000 cubic feet. Therefore the amount of jugs that would fit into the room would calculate out to be 200,000 cubic feet ÷ .19 cubic feet/gallon jugs which equals 1,052,632 gallon jugs in one gym.

   How many gyms filled with jugs would it take to store 35 billion gallons?

   Now with the image of the amount of jugs that it would take to fill one gym in their minds, have the students take the process one step further by calculating how many gyms filled with jugs it would take to store 35 billion gallon jugs of water. Following our current example, 35,000,000,000 gallons ÷ 1,052,632 gallons/gym would equal 33,250 gyms filled with jugs. At this point, remind the class that this is the amount of space that the Neversink Reservoir uses to store its capacity of 35 billion gallons of water.

4. Next, continue comparing the reservoirs by asking the students to perform the same mathematical equations for the water capacity of the Pepacton Reservoir which holds more than 140 billion gallons. Following the Pepacton's equations, a good additional comparison is the Jacqueline Kennedy Onassis distribution reservoir at Central Park which only holds 1 billion gallons. It's important to examine the smaller reservoirs in addition to the immense ones so that one does not lose sight of the fact that though they are smaller than the collecting reservoirs, the capacities of the balancing and distribution reservoirs are still quite large.

Variations:

- Another way of looking at these enormous numbers is to take the gallon jug measurements and ask the students to calculate how far they would have to travel in order to line up each of the 35 billion gallon jugs side-by-side.

- Other activities that help students comprehend the magnitudes of the numbers million and billion are listed in this guide's lesson *One In A Billion*.

Watershed Discussion Questions:

- Why does New York City need so many billions of gallons of water in storage?
- What happens to these reservoir supplies when there is a drought in the Catskills?
- What happens to these reservoir supplies in the spring when the snow from the mountains melts?

Gallons Per Minute

Grades: middle and upper
Objective: to calculate the quantity of water flowing in a stream at a given time
Subjects: Earth and Life Sciences, Physics, Math, Social Studies

Materials: A small section of stream with flowing water, tape measure, a ruler or other method for determining water depth, a float, stop watch, paper, pencils, calculator

Information:

"Most streams appear to travel through a country with thoughts and plans for something beyond." - *John Muir*

A watershed is defined as an area of land from which rain and melting snow drain into a river, stream or other body of water. The Catskill-Delaware Watersheds of New York City's water supply system, for example, collect rain and water seepage from over 1,500 square miles of land. Monthly precipitation readings recorded from the United States Geological Survey's studies sites at Biscuit Brook in Frost Valley during 1983-86, found that the rain/snow fall was greatest during the early spring and late fall yet the seasonal distribution of the precipitation can be variable. Parker and colleagues (1964) noted that the minima and maxima precipitation rates for the area are both likely to occur in the late summer and early fall when thunderstorms and hurricanes can deliver large but unpredictable volumes of rainfall to the region. During these seasons, the precipitation that falls flows directly into the streams rather than being locked up in snow or ice.

The annual volumes of precipitation also vary with the elevation and locations of the mountains. The greatest annual volumes are recorded in the central, high-elevations zones such as Slide Mountain and Frost Valley (Stoddard and Murdoch). While monitoring the average annual precipitation over a 10-year period, Murdoch and his group at the USGS found that stations just outside the Catskill Mountains to the west and south received 32% and 46% less volume respectively than the Slide Mountain station. Precipitation at the Biscuit Brook NTN station averaged 57.1 inches of water per year with an average annual snowfall of 8.4 inches (snow water equivalence) for the same period of time in 1984-86 (Murdoch).

Where does all of this water go? The contours and streams of the Catskill Mountains serve as a delivery system for these flowing waters toward the collecting reservoirs in elevations below. During heavy rainfalls or excessive snowmelts combined with storms, the streams and rivers of the mountains are known to rise quickly to dangerous flash flood conditions in a matter of hours. The following pictures show views of Biscuit Brook at Frost Valley at its normal flow stage and also during a flash flood following a storm that delivered over 8 inches of water in two days. That storm increased the stream's flow rate from an annual average of about 5-10 cubic feet/second to 700-800 cubic feet/second at the discharge's peak. That means that the incredible amount of 5,894 gallons of water/second were flowing down Biscuit Brook due to that storm.

Frost Valley's Biscuit Brook Spillway at its normal flow.

Biscuit Brook Spillway flow as the storm ended.

Small streams, however, do not actually need flooding conditions in order to deliver large quantities of waters. Even the smallest of tributaries drain major volumes of water if you consider the gallons flowing over a period of time.

The following activity will guide students through the measurement procedures in quantifying the amount of water that flows down a particular stream during just one given day. Your class does not need a large or major stream in order to conduct this activity. A small to medium sized waterway is perfect for this lesson.

Procedures:

1. Begin by finding a small stretch of a stream that is fairly straight and even flowing. Mark two check points, one at either end of a 25 foot stretch of the waterway. Refer to them as Points A and B.

2. Next, drop a float (cork or small sticks float well and are also biodegradable) into the water a fair distance upstream from point A. This distance will give the float the opportunity to reach the full velocity by the time it reaches the beginning point. *Note: If there is a chance the float will escape downstream, it is best to use something that will not harm any of the wildlife of the area. Oranges and grapes float well, but as was noted at a recent teacher training done by Cornell University, limes and lemons sink quickly.

3. Time the float during its progress from Point A to B. Catch the float after it passes Point B by using a net or a pair of very quick hands. Repeat the trial. Using the average value between the two measurements, calculate the velocity the float was traveling in ft./sec. This can be done by using the following formula:

   A to B first trial = 25 feet in 10 seconds
   A to B second trial = 25 feet in 14 seconds
   50 feet ÷ 24 seconds = 2.1 feet/second

4. Next, measure the depth and width of the stream in several areas within the section. Average these values and use them to find the area of the stream. The students may find this value and convert it into square feet by using the following formula:

site	depth	width
#1	20"	60"
#2	27"	63"
#3	33"	69"
#4	24"	56"
	104" ÷ 4 = 26"	248 ÷ 4 = 62"

   Area = 26" x 62" = 1612 square inches
   1612 sq. in. ÷ 144 sq. ft. = 11.2 square feet

5. In order to correct for the higher stream velocity compared to the mean stream velocity considering all depths, use the velocity coefficient of 0.85 in the following formula:

   velocity x coefficient = adjusted velocity
   Example: 2.1 ft/sec x .85 = 1.785 ft/sec.

6. The next step in the calculation is to use the adjusted velocity and the area of the stream being measured to find the volume of water passing per second. This can be done by multiplying the adjusted velocity by the area and the answer will be measured in cubic feet per second.

   Example: 1.785 ft./sec. x 11.2 sq. ft. = 20 cubic feet/second

7. With this value, the students may then find the quantity of the stream flow by multiplying the volume by the conversion constant 1 cu ft contains 7.48 gallons.

   Example: 20 cu. ft./sec. x 7.48 gals./cu. ft. = 149.6 gallons/second

8. If the time is available to you, it is interesting to return to the same site at a later time and measure it again. Did the flow increase or decrease? What do you think accounted for the change? Whether you are able to return at another time or not, a concluding discussion for this activity can explore a wide range of subjects including: the physical qualities that make this stream fast or slow moving, the adaptations of the wildlife of this aquatic environment, the amount of waters traveling past you and their final destination as well as the quality of the waters in this waterway.

Variations:

- If you do not have a net available to catch the float, this experiment also works well with the float tied to a measured amount of string and sent down the water's current that way. With this method, you are insured of the retrieval of your float and you know for certain when the float has reached the desired distance.

- This activity can also be done in an urban gutter if a stream is not available. It is particularly interesting to do it in a storm gutter after a heavy rain. Students will be surprised by how much water is actually running by them due to that storm.

- An interesting dimension to add to this experiment is to have the students also prepare and monitor rain gauges for this period of time noting how rainfall influences the waterway's flow. For more information on constructing rain gauges, see *Counting Raindrops* in this guide's hydrology section.

Watershed Discussion Questions:

- What physical structures do people build in a river to slow or divert its flow?
- When the water is flowing quickly in a river due to a rain storm, how does that affect the quality of the water for drinking?
- What are some ways in which people use the power and quantities of the waters in fast flowing rivers and streams? What are two examples of these methods in New York City's Water Supply System? (Hint: Take a closer look at the Delaware System. It is capable of supplying water and electricity to communities.)

Source: Adapted from *Stream Flow* in The Official Captain Hydro Water Conservation Workbook

Monitoring the Quality of the Quantities

New York City's Department of Environmental Protection's Water Quality Control Laboratories

> According to the World Health Organization, globally, 1.5 billion people do not have a safe supply of drinking water and 1.7 billion lack adequate sanitation facilities. At least 5 million people die every year from waterborne diseases that could be prevented by clean drinking water and better sanitation.

When talking about New York City's water supply system, its immense reservoirs and long distances of underground aqueducts, it is easy to concentrate on the massive quantities of waters involved. But of special interest to the Bureau of Water Supply's Division of Drinking Water Quality Control and the City's citizens is the potability of these waters. In order to insure safe drinking waters for the City of New York and its surrounding communities, the NYC Department of Environmental Protection (DEP) maintains a series of laboratories and monitoring facilities that keep a close watch on the quality of this vital resource.

Watching For Potential Hazards

There are many things that could make a water source nonpotable. Some are physical or aesthetic concerns such as color, turbidity and algae which may alter the appearance, taste, and odor of the drinking water supply. Others are more of health related concerns which include the presence of excessive sediment, large amounts of metals, pesticides or other chemicals, microscopic plants and animals including coliform bacteria, viruses, and the pathogenic organisms referred to as the "superbugs" such as *Giardia* and *Cryptosporidium*. Many of these health concerns are quite serious considering the fact that the gastrointestinal organisms known as enteric pathogens in particular are capable of making a person gravely ill or even killing susceptible individuals. In natural water sources there are also the cumulative dangers of metals or chemicals capable of causing damage through long periods of exposure (For more information, see *The Bioaccumulation of Toxins*.)

Sources of the various types of contamination differ but many can be traced to either human or animal activity within the watershed. Many forms of enteric pathogens, for example, can be traced to an untreated or defective sewage system, agricultural runoff or wildlife contamination. It is, therefore, the responsibility of the city of New York's DEP's Division of Drinking Water Quality Control laboratories and monitoring stations to detect any potential hazards to the quality of the city's drinking waters. The defenses that the DEP employs against the deterioration of the water supply's quality takes on three main strategies. These defenses include: pollution prevention measures in the watersheds, using natural processes, and treating by chemical and mechanical means.

Watershed measures involve research into the dynamics of the watershed areas and identifying the regions of potential concern; zoning and land use management; and the monitoring, surveillance and enforcement of watershed regulations. The second line of defense is letting nature treat the water itself. Natural sediment settles, through the pull of gravity, the cloudiness or muddiness of any turbid waters. Natural disinfection happens when many disease-causing organisms, or pathogens, simply die off when sunlight, temperature or lack of available food supply affect their life-cycles. Other natural cleansing processes such as natural filtration through soils and vegetation, aeration in turbulent water and reservoir turnover throughout the seasons act on the waters as they pass through the watershed and reservoir systems. When natural processes are not effective enough to control or eliminate pollution, human intervention is then necessary. This can be done through chemical means, flocculants and disinfectants, or mechanical means. Mechanical manipulation of the reservoir facilities used to insure the highest quality waters delivered to the city include: altering of the reservoir levels which destroy organisms through exposure to air or ice; withdrawing the waters from healthier layers of the reservoirs; or bypassing and isolating reservoirs that are experiencing water quality problems.

Monitoring the Quality of the Waters

New York City's DEP has a series of labs that monitor various vital locations in the water supply system and conduct extensive observations at certain times seven days a week. The four upstate laboratories are located in Grahamsville, Shokan, Valhalla and Brewster with an additional lab located in Corona, New York. The upstate labs such as the one in Grahamsville which monitors the Delaware System's reservoirs and aqueducts, have the task of insuring the best quality of waters possible while still delivering the quantities needed in the city. Though the mountains of the Delaware Watershed often deliver pristine, safe waters, testing and monitoring is essential to insure the highest quality possible. The analyses schedule run by the Grahamsville lab monitors a wide variety of substances on an annual, semiannual, quarterly, monthly, biweekly, weekly and even daily basis. The analyses record and monitor physical, chemical as well as biological variables in the waters and surpass the water quality testing done by many of the bottled water companies. The following is a brief list of many of the variables the upstate labs monitor on a regular basis.

- **Physical Analyses**
  Turbidity, Color, Taste and Odor, Conductivity, Temperature and pH
- **Chemical Analyses**
  Alkalinity, Chlorides, Ammonia/Nitrate/Total Nitrogen, Phosphorous Compounds, Silica, Total Organic Carbon, Trihalomethanes, Trace Metals, Solids, Chlorine Residuals, Fluoride, BOD and Dissolved Oxygen
- **Microbiological Analyses**
  Phytoplankton and Zooplankton, Total and Fecal Coliforms

By testing the above perameters, the scientists and water ecologists are then able to predict with a great deal of accuracy the occurrence of many water contaminations. For example, the labs are able to predict the growth of a colony of diatoms (unicellular algae) by knowing the environmental conditions such as water temperature and chemistry and specifically looking at the amount of Silica materials available to the organisms. For excessive growth of this population, the diatoms will need the proper conditions as well as enough Silica for them to use in building their glass-like cell walls. In this way, the scientists are able to utilize nature's own cleansing methods to avoid unnecessary chemical additions to the waters predicting when diatoms will have the proper conditions for continued growth.

Concerns such as algae blooms may also be avoided by utilizing the system's mechanical methods designed into the reservoir intake devices. The Rondout Reservoir at capacity, for example, is 150 feet deep at the location of the intake tunnel. Pipes leading from the reservoir into the water tunnel are available at various depths in the water from 827, 795, 763 and 730 feet above sea level. Depending on various conditions, the DEP personnel determine which intake pipe they wish to draw from on any given day. For example, on a sunny summer day when the phytoplankton in the reservoir are abundant in the surface waters, water may be drawn from a lower intake pipe is used to avoid the algae colony altogether. When algae blooms cannot be avoided, which is quite rare, a small amount copper sulfate is added to the waters to kill the organisms responsible for this event. This addition unfortunately is said to affect many other members of the aquatic environments especially numerous fish species. Therefore, approval must first be obtained from the New York State Department of Environmental Conservation to insure safe limits are implemented.

Many of the reservoir systems are not as fortunate as the Delaware in regards to receiving high quality waters. Urban development, inefficient sewage treatment plants/systems and the proximity of animal populations, both domestic and wild, can lead to serious contamination of the reservoir's watersheds. These situations often call for chemical intervention for the sake of water quality. At times, tests identify high levels of contaminated sediment flowing toward the impoundments in many of the reservoir tributaries leading from water treatment plants, including those in the Delaware System. In order to draw out those particulates from the water columns, the DEP adds Alum to the waters which serves as a flocculant binding to the solids and pulling them down to the stream's bottom out of the water currents. For more information on this form of water pollution, see *The Trouble With Turbidity* and *Cleaning-up Our Wastewater*.

If additional cleaning is necessary in the reservoirs for this or other reasons, chlorine is often added to the water as it enters the intake tunnels. The form of chlorine that is used is chlorine gas which is highly volatile out of solution meaning that it quickly dissipates and does not remain in the waters if the water is still outside of the tap over night. Because of its volatility, chlorine is then able to kill potential disease-causing pathogens that may be present in the waters due to watershed contamination but will not remain in the drinking water supply itself beyond an initial minute residual amount.

Chlorine is effective in killing many of the enteric pathogens commonly found in water supply systems but it is unable to dissolve the membranes protecting the cysts of the industry's "superbugs", *Giardia lamblia* and *Cryptosporidium*. Both of these organisms are protozoans which use warm-blooded animals as hosts. These disease-producing organisms are measured by micrometers. It has been calculated that approximately 10,000 Giar*dia* would fit on the head of a pin. The cysts of these organisms are even smaller than the organisms themselves and are capable of surviving for up to one year under the most hostile conditions. Both organisms can cause seriously debilitating illnesses in even the healthiest individuals and possible death to those with suppressed immune systems. Infection would require the ingestion of just one of these tiny oocysts. Virtually any animal found in a watershed can be considered a potential carrier of these organisms, although cattle seem to be a significant host.

Detection of these microscopic menaces is difficult, time-consuming and expensive. New York's DEP tests for *Giardia lamblia* and *Cryptosporidium* at the Kensico Reservoir and Croton Lake sites weekly and monthly at approximately 30 different sites in the streams, rivers and reservoirs throughout all three watersheds. Scientists throughout the country are searching for effective treatments for ridding water sources of these harmful organisms. The most current high-tech filtering systems available have proven to be expensive, tedious and at times dangerously ineffective as shown by the drinking water contamination in Milwaukee, Wisconsin (April 1993) in which 400,000 people became ill from *Crypto*-contaminated water. When scientists consider the fact that *Cryptosporidium* oocysts are able to survive over 24 hours in a 50,000 parts per million concentration of bleach, they must then search for other possible filtering or heating procedures that may stop the spread of the organisms. Heat has proven to be very effective against *Giardia*, but until a feasible solution is found for the "superbug" outbreaks found in the reservoir systems, the best method the DEP has found is to work on eliminating the sources of the initial contaminations. Farming communities in the Catskill watersheds are currently working with the water supply officials to stop any possible contamination from agricultural practices in these regions (For more information, see *Community Solutions to Water Pollution*). Unfortunately, the DEP estimates that most of these types of contaminations are due to the wildlife that call these watersheds home.

Testing For Potability

At the Kensico Balancing Reservoir and the Hillview Reservoir, which are located just outside White Plains and in the city of Yonkers respectively, additional testing and treatments are performed in order to insure that these waters are not only "clean" but safe and potable. At the testing facilities on the reservoirs close to the city as well as the lab inside the city, scientists monitor the same water quality variables that the upstate labs perform. In addition, these labs also watch for any pesticides or any other chemical concerns. All of the DEP's laboratories are mandated by Federal and New York State Health Laws to perform intensive observations insuring the citizens safe water. It is interesting to note that New York State's water quality laws are stricter than the Federal Water Quality Regulations.

Of special interest to the labs at the balancing and distribution reservoirs is the potability of the waters. Potability not only takes into account the appearance, odor and taste of the waters but also the safety of the water's contents. The goal of these laboratories is to watch for any of the possible contaminants that would affect human health and institute treatment standards for cleansing these waters using the means available to them.

In watching for possible pathogens, the labs extensively monitor the coliform bacteria of the waters because they are good indicators of fecal contamination. Coliform organisms, though considered relatively harmless themselves, are almost always present in water containing enteric pathogens. Since coliforms are easy to isolate and they normally survive longer than the disease-producing organisms, they are very useful in finding the hard to locate dangerous species. In most cases, water that is free of total coliforms is considered to be free of pathogens. Bacteria testing is used in the Kensico Reservoir where the waters are routinely chlorinated entering and exiting the water impoundment as well as several hours down the system at the Hillview Reservoir. Through testing, the labs have found the chlorination helps in ridding the Kensico waters of contamination but the Hill View Reservoir is again exposing the water to potential pollution from its watershed making an additional chemical treatment necessary there. The quantities of chlorine the scientists use are generally 1 ppm of chlorine gas to water. This amount dissipates quickly when the water is left sitting over time. To insure that those doses of disinfectant are enough, the labs also test 100 sites throughout the city for possible bacterial contamination. If an area of contamination is isolated, the scientists are able to flush the local system and temporarily boost the chlorination to that zone.

Other chemicals which are added to increase the water's potability are fluoride, added for dental hygiene as required by the state and federal governments, and also corrosion inhibitors. These inhibitors are added due to the nature of the very old plumbing in a majority of the city's buildings. Lead pipes were commonly used in many of the plumbing systems in buildings built between the 1920s and 1940s. Since that time, lead has been found to be a serious health hazard to humans and other animals. Exposure to lead over a period of time may produce a build up in the body that could cause damage to the brain, red blood cells and the kidneys of children in particular. In order to prevent leaching of this dangerous metal into the drinking waters throughout the city, in 1992 the officials started adding Orthophosphate which binds with the lead in the pipes. Sodium hydroxide is also used in the waters entering the distribution grid in order to raise the pH of the water making it less corrosive on the aging plumbing systems.

Continuing to Count on the Quality

For decades, New York City citizens have been able to depend on the reliability and quality of their water supply. Through the system's watershed, natural, chemical and mechanical defense strategies, New York City's Department of Environmental Protection has been able to deliver the highest quality water possible during this time period. Continued assurance of this water's quality, facing increasing urbanization and watershed development will necessitate careful and practical planning for the future of these regions. It is only through cooperation of the watershed communities, scientists, federal, state, and city officials, can the quality of these quantities be insured for the future.

Sources: Water supply system information supplied by NYC's DEP offices

Is It Clean?

Grades: middle and upper
Objective: to explore the quality of a seemingly clean source of water
Subjects: Earth and Life Sciences, Chemistry, Social Studies, Health

Materials: Four small jars with the following water samples: pure, clean tap water; half clear water, half rubbing alcohol; muddy water; and water filled with sand or gravel, also additional jars of clear water and a variety of household chemicals

Information:

"To date, more than 700 chemicals have been detected in the United States drinking water, 129 of which the Environmental Protection Agency calls dangerous, including industrial solvents, metals and radioactive substances." - *Only One Earth*

Water quality is a survival concern for many people in our world today. How clean is our water source and how can we tell? Extensive steps are being taken within the commmunities of the Catskill Mountain watersheds to insure the quality of their sources of pristine water. In addition, the NYC Department of Environmental Protection goes to great lengths to test and monitor the quality of the water destined for city-dwellers' taps.

The following activity will point out to students that testing for water quality is not as simple as looking at it and there are just reasons behind the Catskill communities' and New York City's efforts in safeguarding the quality of their shared vital resource.

Procedures:

1. After a discussion on water quality, present the prepared jars of water to the class. With only a visual observation, ask the students to choose which water they would drink. Now give them the opportunity to smell the jars and change their choice if they desire. Discuss the abilities of chemicals to "hide" in water and the dangers involved. For more information on this subject, refer to this guide's chapter on water pollution.
2. As a further demonstration, have the students split into groups of three or four. Give each group a jar with some water and access to a variety of household chemicals (cleaners, disinfectants, vinegar and other foods, etc.). Take care to instruct the students on the safe ways of working with and disposing of these types of chemicals. Challenge the groups to use the scientific method to mix together a polluted water jar that appears clean visually. Have the students record how many chemicals they were able to add to their samples without changing the appearance of the water.
3. Conclude with a discussion on the different methods communities use to clean-up their water sources once contaminations are detected. This is also a great opportunity to discuss the preventative plans used in the Catskill communities that aim to avoid water pollution before it happens in their watersheds. (See *Catskill Community Solutions to Water Pollution*)

Watershed Discussion Questions:

- How does New York City insure the quality of its drinking water?
- What regulations do the NYC officials need to follow concerning the water quality?
- When you are looking at a water source, which is more important quality or quantity?

Source: Adapted from *It Looks Clean* in Linking Your Y With The World

Water Carry

Grades: all grade levels
Objective: to experience how people in developing countries obtain safe drinking water
Subjects: Earth and Life Sciences, Chemistry, Social Studies, Health

Materials: A scarf or cloth, a bucket or pot, several gallons of water

Information:

In many developing countries, women in a family are often the water carriers. It is thought that the average woman can carry about 15 liters (3.9 gallons) of water in comfort. "Water is heavy; many pots and buckets carried on the head weigh more than 25 pounds when full; 4.7 gallons of water (18 liters) in plastic cans could weigh more than 40 pounds. It is not uncommon for a woman in some parts of Africa to spend five hours a day hauling water." -The New Internationalist, May 1990

Students in New York City and upstate communities who are not aware of the hardship people in other parts of the world endure in order to obtain safe drinking water may take their conveniently located tap of clean water for granted. The New York City water supply system, for example, delivers approximately 1.4 billion gallons of clean water to the Big Apple daily. There was a time in the City's history though, before the watershed collecting systems were developed, when the people of New York City were plagued with a polluted drinking water supply. (For the history of New York City's water supply, see *From Wells to Watersheds*)

The following activity will increase the students' awareness of the great distances women and children in many developing areas must travel for safe drinking water.

Procedures:

1. After discussing the importance of substantial amounts of clean water to insure a family's survival, explain to the students the efforts people in developing countries endure for their drinking water. An average family in a developing area needs approximately 40 liters (10.5 gallons) of water daily to survive. Encourage the students to try to carry this amount of water for a distance. Use a cloth to make a ring for supporting the bucket on their heads.
2. Discuss how it feels to go through this effort for your drinking water. How many trips would you need to do in order to get enough water for your family? What if you had to travel a great distance for the clean water? How does working together help to complete this job more quickly and safely? For fun you might use this activity as part of an obstacle course or include it in a truly challenging orienteering course.

Watershed Discussion Questions:

- How long would it take you to walk to the original source of your water supply?
- New York City developed its immense water supply system because their local water sources were contaminated. If you had a choice between drinking polluted water or walking a minimum of one mile for clean water, which would you choose?
- Water treatment plants cost a great deal of money to build and maintain. If you had a choice between drinking polluted water or paying additional taxes to support a new water treatment plant, which would you choose?

Source: Adapted from *Carrying Water On Your Head* in Taking the World to Camp

The Technology of the Watersheds

Assessment Tools

Getting to Know the Water Supply System

> "You will never completely master a river, swamp or any other wooded area, unless you repeatedly traverse it, and you can not do this until you know how the land lies, what are the prominent landmarks, and what are the feasible routes to follow in exploring it." - *Henry E. Davis*

As students continue to learn about New York City's complicated and impressive water supply system, it is necessary that we, as educators, do not stop short of presenting the entire picture including all of the aspects of this utility. Through this chapter's discussions and activities, students should have a basic understanding of New York City's water supply system and how it works. Many of the activities in this chapter can serve as assessment tools themselves considering the techniques and formulas of the lessons. A concluding activity that would serve to solidify the information for the students would be to challenge them to create a miniature facsimile of the watersheds and supply system.

The following are some suggested mediums to use in the student's re-creations in order to increase your students' comprehension of the dimensions and locations of New York City water supplies.

Map Maker, Map Maker . . . :

- As an art or math activity, have the students draw maps outlining the dimensions and locations of the facilities involved in delivering water to New York City. These should include the watersheds, the reservoirs, tunnels, mains, interior plumbing and taps of the delivery system.
- Expand these art projects into the creation of a class mural.
- In using another medium, have the students use clay, cups and straws in order to create their own miniature version of the supply system.

We All Live In A Watershed:

- Encourage students to explore their own watershed by mapping out where their neighborhood's precipitation flows following a rain storm. Include any possible sources of pollution found in their drainage area.

The Technology of the Watersheds

Class Follow-up Projects

Exploring the Water Supply System

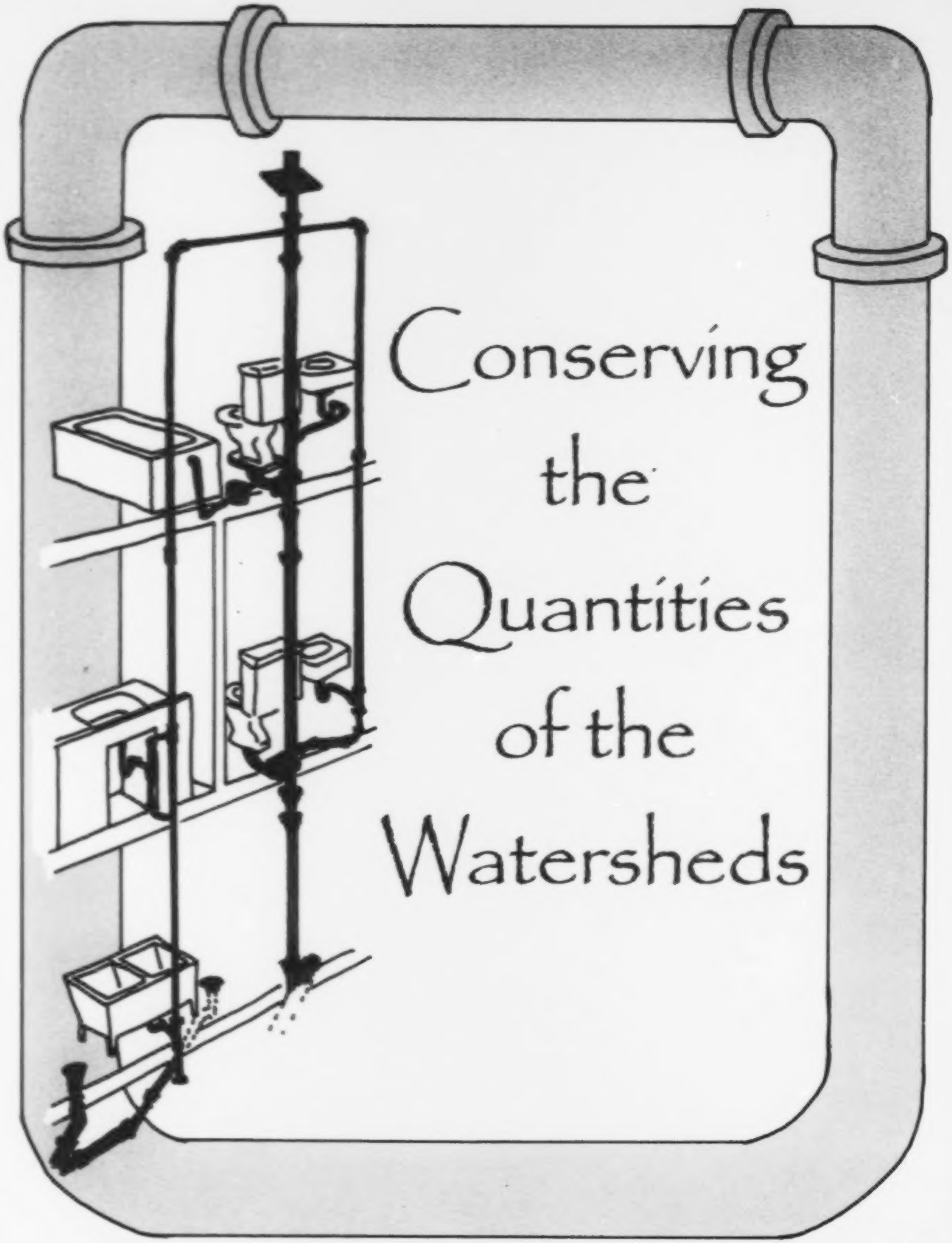
If after studying this section on New York City's Water Supply System the class is eager to build on these lessons, here are some ideas for some successful follow-up activities and interesting class enhancements involving in-depth looks at this immense utility.

Taking A Closer Look:

- A great opportunity for students to learn more about this system would be to meet a professional from the New York City Department of Environmental Protection so that students may learn about his/her job and responsibilities. For more information on possible guest speakers, contact Kim Estes-Fradis, the Director of Education at the DEP's offices in Corona, New York, (718) 595-3506.

- In exploring the system itself further, the New York City Department of Environmental Protection offers opportunities to tour certain facilities in the water supply system. For more information of tours and free publications for schools upstate and down, also contact Kim Estes-Fradis, Director of Education at the DEP's offices.

- Don't limit your look at the water supply to the constructed delivery structures. Take the opportunity to explore the natural sources of the waters in the watersheds themselves. Located in the heart of New York City's Delaware Watershed, the Frost Valley YMCA Environmental Education Center offers day and resident trips at their site which provide students with firsthand observations of the origins of the water supplies. For more information, contact the Frost Valley YMCA's Director of Environmental Education at (914) 985-2291.



Conserving the Quantities of the Watersheds

Conserving the Quantities of the Watersheds

This section of our guide includes the following:

- information inserts - 🚰 - on the subject of water conservation
- a variety of activities exploring topics in water consumption, conservation and how these dynamics affect the ways of the watersheds

🚰 *Making Every Drop Count*

Conserving the Quantities of Our Water Supplies

Drought Days

to brainstorm techniques and problem solving strategies in order to effectively utilize a limited supply of water

Tap Tallies

to illustrate the amount of water people use during their daily routines

Wise Water Usage

to illustrate how much water conservation-minded households are able to save

Considering Quantities

to explore possible water conservation measures needed during drought condition

How Wet Is Your Home? - A Home Water Use Survey

to encourage students to investigate how water is used in their own homes

🚰 *Ways To Save Water*

Simple Conservation Tips for Water Uses at Home

The Silent Water Waster

to demonstrate how to detect a leaking toilet system

Shower Timers

to enable students to make their own water timer as a home water conservation tool

A Sharing Story

The Ways of the Watersheds Stewardship Award
to encourage students to take an active part in the conservation of the quality and quantities of water

YMCA Youth Earth Service Corps
Learning To Keep The Earth Fit For Life

Making A Difference - Youth Action
to involve students in the protection of their local water resource

Stewardship Of The Ways Of The Watersheds
Strategies For Youth Group Actions

Assessment Tools

Class Follow-up Projects

Making Every Drop Count

Conserving the Quantities of Our Water Supplies

> "...given the fact that water is the precious resource upon which terrestrial life depends for sustenance, one might suppose that human beings would be respectful of water; that they would seek to maintain its natural reservoirs and safeguard its purity."
>
> *- J. W. Maurtis la Riviere, Secretary-General, the International Council of Scientific Unions*

When we study the subjects of water, learning about its properties, distribution, uses and misuses, it is easy to overlook the fact that though this resource covers 75% of our planet only a mere 1% of that amount is available for us to meet our needs. We often hear of people in developing areas around the world with insufficient supplies of quality water. It is interesting to note that water quantity is becoming just as important as its quality when it comes to health due to the fact that a lot of water is often needed to keep the body and household clean. The key to obtaining adequate amounts of water daily for people throughout the world is the distribution systems used. For example, the publication *The New Internationalist* came out with significant household water consumption statistics in May of 1990. Observing data from around the world, they stated the following:

- Households with dishwashers, washing machines and sprinklers used 1,000 liters of water per person per day.
- Households with a piped supply and taps used 100-350 liters of water/person/day.
- Households using a public hydrant in the street for their water used 20-70 liters of water/person/day.
- And households depending on a stream or handpump several miles away used only 2-5 liters of water/person/day.

When not thinking about conservation, people often use as much water as is available to them. This is especially true for people in the United States. It is said that the average adult needs two and a half quarts of water per day in order to maintain good health. In the United States, each person uses 125 to 150 gallons of water daily for cooking, washing, flushing and watering. That calculates out to be over 40% more than we need to accomplish these tasks.

Wasted Water?

Whether water is wasted through habits that deplete clean water reservoirs faster than they can be replenished or by the use of antiquated, water-wasting equipment not built with conservation in mind, the average resident of the United States in known to consume more than 70 times as much water every year as the average resident of Ghana. Water wasting habits can be difficult to change, but new habits can save thousands of gallons of water a year for just one person. Water saving fixtures are often inexpensive, easy to install, and they can save large quantities of water without changing daily routines. By following simple conservation steps, a typical family of four can save an astounding 50,000 to 100,000 gallons of water per year.

Often when rural New York residents look at their vast underground water supplies or New York City residents look at the giant water reservoirs available it is difficult to see the reason to conserve this resource. Though there are people all over the world that could tell us that the time to start thinking about conserving water is not when the drought starts.

Drought Days

Grades: elementary and middle

Objective: to brainstorm techniques and problem solving strategies to effectively utilize a limited supply of water

Subjects: Earth and Life Sciences, Math, Social Studies

Materials: A plastic milk jug for every student, paper and pencil, calculators (optional)

Information:

In the United States alone, industry uses over 100 cubic miles of water per year to cool, wash, circulate and manufacture its materials. This is 30% of the water in the world's rivers.

Water is a precious natural resource to us and although it covers a majority of the earth's surface, these quantities are not all available to us. Only in considering the many uses we have for water do students realize the amounts we as a society actually consume on a regular basis. The discovery of this fact is the beginning of any conservation ethic we may be able to encourage students to adopt.

The following activity is an interactive way for students to quantify first-hand exactly how much water they consume for one day's worth of their regular routines.

Procedures:

1. Introduce this activity with a discussion of our society's water uses. Have the students list on the board all of the different ways in which we and our communities use freshwater supplies daily.

2. Next, have the students make their own personal lists of the many ways in which they have used freshwater within the last 24 hours.

3. Instruct the students to make a guess as to how much water (in gallons) all of their daily activities listed consumed. For specific totals for average daily uses of water, see *Wise Water Usage.*

4. Following these calculations, inform the class that for the next week, they will be taking part in an activity called *Drought Days*. During this activity, the class as a whole will be under strict water use watches and except for flushing, there will be no water available from the school. It is the student's task to solve the problems of having a limited water supply for that period of time. Begin the activity by giving each student an empty plastic milk jug and instruct them to bring into school the next day the amount of water they think they will need for a day. Go through a regular school day allowing the children to freely use their water. At the end of the day, have the students see how much water they have left or how much they shared with others in the class. *Note: The quantities of water are greatly increased if you choose to take into account the volumes of water used in bathing, washing dishes, etc.

5. Next, have the class brainstorm the different ways in which they can have water available for their needs under these "drought" conditions. Some possible solutions might be:
    - Carrying water to school in jugs.
    - Building a reservoir in the classroom (large jugs/coolers) to store excess water.
    - Cutting back to essential uses only.
    - Reducing activities or movements.
    - Bringing lunches naturally high in water content: fruit, cheese, etc.
    - Sharing with those who forget their day's supply.

6. Conclude the activity with a discussion of common conservation measures the students can use in their every day lives to cut back on any amount of water they use needlessly. Add in a topic on how certain conservation attitudes and actions can carry over to decisions outside of schools and homes, i.e. NYC sharing water with communities down-stream on the Delaware River, the re-use of water in industries, etc. Continue lessons on conservation topics using any of the other activities listed in this chapter.

Variations:

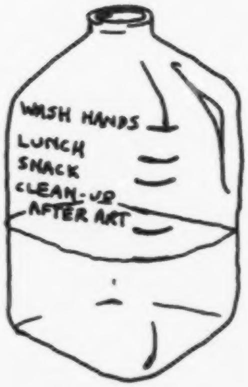
- In order to comprehend the amounts of water they are consuming, encourage the students to take their daily use totals and calculate out how much water they use in one year. Then, using the formulas in the activity *How Big is Big? Calculating Capacities,* instruct the students on how to compute the amount of space their volume of water would take up if it were all stored in one place.

- Another way of visualizing the amount of water the class consumes in one week is to calculate the volumes and then have them collect that amount of plastic gallon jugs to display in the classroom.

Watershed Discussion Questions:

- Why is it important to conserve water on a regular basis?
- Why is it especially important for New York City dwellers to conserve their water when it has not rained in the Catskill recently?
- How large is your community's water supply?

Source: Adapted from *Desert Days* in My World, My Water and Me



Tap Tallies

Grades: all grade levels
Objective: to illustrate the amount of water people use during their daily routines
Subjects: Earth Science, Math, Social Studies

Materials: One sink and tap, a stop watch, a pail that fits in the sink, a liquid measuring container, pencil and paper, calculators (optional)

Information:

Since 1945, New York City's water consumption has increased from 1,056 million gallons per day to over 1,465 million gallons per day. This indicates an average increase of almost 1% annually. - *NYC DEP*

As a population of a community grows, its demand for clean water sources also increases. The challenge of supplying adequate amounts of quality water to communities is often thought to be the soul responsibility of the water supply bureau. Evaluating our water use habits and considering the amount of expense and energy that goes into delivering that water to us serves as a reminder that we have a part in that responsibility also. Through wise use and conservation of our existing water supplies, we need not demand unnecessary depletion of our limited freshwater resources.

The following activity is designed in the form of an experiment that enables students to calculate just how much water is used for our simplest daily routines.

Procedures:

1. Begin with a class discussion exploring the ways in which the students ordinarily use water on a daily basis. Some questions that you may pose to the class could be: What did you use water for yesterday? How much water do you think you used to do those things? Was any of the water that you used wasted?

2. One example of how water is often wasted in a home is someone running the water and waiting for it to get warm before washing their hands. To find out just how much water is wasted through this simple action, have the students perform the following measurements.

   A. Locate a sink with a hot water tap at your school that the students may use for collecting the data. Be sure that the tap is cool before beginning. Wait at least 10 minutes if someone has recently used the sink.

   B. First, place the pail under the tap to collect the water to be measured. Next, have the students turn on the faucet and collect the water until the water becomes warm. As soon as the water becomes slightly warm, run the tap for 5 more seconds and stop.

   C. Take the collected sample to the classroom and measure the amount of water in the pail.

   D. Repeat procedure B for two more trials. Be sure that the water is cool in the tap before beginning each trial. Compute the average amount of water wasted. Continue the calculations by finding the amount of water wasted daily by a larger population such as your town or city.

   The total = average amount of water x # of times a day per person x # of people

3. Following the calculations, conclude the activity by discussing possible ways of solving this problem. Possibilities may include: using cooler water when hotter temperatures are not really needed, locating the hot water tank closer to the sinks or collecting the water for another use.

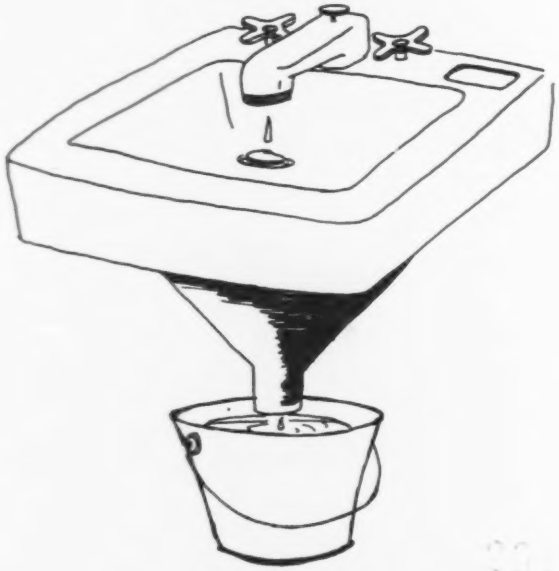
Variations:

- Some fun variations of this activity would include measuring the amount of water students typically use for a variety of other daily routines. The following is a brief list of several actions that are interesting to measure and calculate the amount of water being used or wasted by your town's entire population. Also a great contrast to these amounts would be to repeat these measurements calculating the amount of water wasted while using conservation-minded techniques.
    - Brushing your teeth with the water running / stopping the tap while brushing
    - Washing your hands with the water running / stopping the tap while soaping up
    - Bathing: run a shower or large tap for one minute and calculate the amount of water used for a 10 minute shower.
    - Lawn Watering or Car Washing: run an outside tap for one minute and calculate the amount of water used for 15 minutes of running a sprinkler or washing a car. Then compute how much water would be saved by watering less at the appropriate time of the day and turning the hose off while you soap up the car.

Watershed Discussion Questions:

- How could the gallons of water wasted during your daily routines be otherwise used?
- How could changing your personal habits make a difference to your huge water supply?
- Using the amounts calculated in the experiments, compute how much water would be wasted in 10 years?

Source: Adapted from *Down the Drain* in Water Precious Water



Wise Water Usage

Grades: all grade levels
Objective: to illustrate how much water conservation-minded households save
Subjects: Earth and Life Sciences, Math, Social Studies

Materials: One set of the *Wise Water Usage* cards and answer table

Information:

"The frog does not drink up the pond in which he lives." - *A Native American Proverb*

According to the United States Environmental Protection Agency, a family of four in the United States uses about 243 gallons (920 liters) of water per day in the following ways:

- toilet flushing = 100 gallons (379 liters)
- shower and bathing = 80 gallons (303 liters)
- laundry = 35 gallons (132 liters)
- dishwashing = 15 gallons (57 liters)
- bathroom sink = 8 gallons (30 liters)
- utility sink = 5 gallons (19 liters)

- *The 1992 Information Please Environmental Almanac*

This group dynamics activity is designed to help students explore the actual amounts of water that are used in performing some of our daily routines. The volumes used for the activity reflect the amounts calculated for each individual action in an average household and also for a conservation-minded household.

Procedures:

1. Begin this lesson with a discussion or activity exploring students' daily uses of water.

2. Separate the class into two equal working groups. Give each of the groups one set of the *Wise Water Usage* cards. Take care to give one group the Average Household and the other the Conservation-minded Household set of cards.

3. Explain to the students that each set is made up of cards noting a daily routine and cards showing the amount of water an agency has calculated to be the average amount of water people use for that action. It is their job to match the action cards with the correct water-volume cards. Working as a group, give the students time to discuss and lay out the cards as they decide how the matches should be arranged.

4. After each group has had time to finish their matches, bring the groups together to discuss the actual amounts used in these actions. Note the differences between the Average Household and the Conservation-minded Household's water usage. Discuss the reasoning behind the dramatic differences in the volumes.

5. Continue this lesson by encouraging the class to bring home the *How Wet Is Your Home?* survey. This questionnaire will help students investigate their family's own water use habits and possible water conservation techniques their households could implement in order to cut back on the amount of water they waste daily.

Watershed Discussion Questions:

- If conservation techniques save so much water, why don't many people use them?
- How well did your group work together?
- What are some ways in which people can work together to conserve water?

Daily Activities Water Uses

Answer Sheet

Activity	The Average Household		Conservation-minded Household	
Shower	tap running	25 gals.	wet down, soap, rinse off	4 gals.
Brushing Teeth	tap running	1-2 gals.	wet brush, rinse briefly	1/2 gal.
Tub Bath	full tub	36 gals.	low water level	10 gals.
Toilet Flush		5 - 7 gals.	with a tank displacement or low-flush toliet	4 gals.
Dish Washing	tap running Dishwasher full cycle	10 - 30 gals. 16 gals.	using a dish pan Dishwasher short cycle	5 gals. 7 gals.
Shaving	tap running	20 gals.	using a basin	1 gal.
Hand Washing	tap running	2 gals.	using a basin	1 gal.
Clothes Wash	full cycle	60 gals.	short cycle	27 gals.
Lawn Watering or Car Washing	tap running	10 gals./min.	stopping tap	10 gals./min.

Wise Water Use Cards

Water Use In an average household **Shower**	Wise Water Use In a conservation household **Shower** wet down, soap up, rinse
Water Use In an average household **Brushing Teeth** tap running	Wise Water Use In a conservation household **Brushing Teeth** Wet brush, rinse briefly
Water Use In an average household **Tub Bath** full tub	Wise Water Use In a conservation household **Tub Bath** low water level

Water Use

In an average household

Toilet Flush

Wise Water Use

In a conservation household

Toilet Flush

with a tank displacement

Water Use

In an average household

Dishwashing

tap running

Wise Water Use

In a conservation household

Dishwashing

using a dish pan

Water Use

In an average household

Dishwashing

dishwasher full cycle

Wise Water Use

In a conservation household

Dishwashing

dishwasher short cycle

Water Use
In an average household

Shaving
tap running

Wise Water Use
In a conservation household

Shaving
using a water basin

Water Use
In an average household

Handwashing
tap running

Wise Water Use
In a conservation household

Handwashing
using a water basin

Water Use
In an average household

Clothes Washing
washer full cycle

Wise Water Use
In a conservation household

Clothes Washing
washer short cycle

Water Use

In an average household

Water Lawn / Wash Car

tap running

Wise Water Use

In a conservation household

Water lawn / Wash Car

wet down, soap up, rinse

Water Use

In an average household

25 gallons
of water

Wise Water Use

In a conservation household

4 gallons
of water

Water Use

In an average household

1 - 2 gallons
of water

Wise Water Use

In a conservation household

1/2 gallon
of water

Water Use

In an average household

36 gallons of water

Wise Water Use

In a conservation household

10 gallons of water

Water Use

In an average household

5 - 7 gallons of water

Wise Water Use

In a conservation household

4 gallons of water

Water Use

In an average household

10 - 30 gallons of water

Wise Water Use

In a conservation household

5 gallons of water

Water Use

In an average household

16 gallons
of water

Wise Water Use

In a conservation household

7 gallons
of water

Water Use

In an average household

20 gallons
of water

Wise Water Use

In a conservation household

1 gallon
of water

Water Use

In an average household

2 gallons
of water

Wise Water Use

In a conservation household

1 gallon
of water

Water Use

In an average household

60 gallons
of water

Wise Water Use

In a conservation household

27 gallons
of water

Water Use

In an average household

10 gallons
of water / minute

Wise Water Use

In a conservation household

10 gallons
of water / minute

Considering Quantities

Grades: all grade levels
Objective: to explore water conservation measures needed during drought conditions
Subjects: Sciences, Math, Social Studies

Materials: Paper and pencils

Information:

"You must do the thing you think you cannot do." - Eleanor Roosevelt

According to *The American Heritage Dictionary*, two definitions of the word conserve are " 1a. To protect from loss or depletion." and "b. To use carefully, avoiding waste." Unfortunately, to many people conservation means limitations and sacrifices. One major goal in water conservation education is to correct this misconception and teach people that conserving a resource does not mean doing without. Wise water conservation is simply re-evaluating current usages and cutting back on wastefulness.

The following simulation activity will put students in the position of evaluating how they use their water sources and where they would conserve if they were put into an unavoidable drought situation.

Procedures:

1. After discussions and activities exploring our daily water uses, introduce this activity as an opportunity for the students to evaluate their personal water consumption.

2. Begin by arranging the class in working groups of five students each. Instruct the groups that they will be simulating or acting out the decisions of a family living in Queens. Read the following situation paragraph to the groups.

Considering Quantities Situation

You are a family of 4 people, 2 adults (parents, or grandparents, etc.) and 2 children (ages 15 and 12). Your house has two bathrooms, a dishwasher and a washing machine. There is a lawn in front of your house and the yard in the back is planted with 4 fruit trees and a variety of flowers and vegetables. Your family has two cars which are usually washed each week. Typically, the average family of four in the United States uses 243 gallons of water a day.

3. Next, give the groups some time to talk about the characters they have in their family and ask them to make a list of how they typically use water in this household.

4. After a short time, give the following task to each group:

   You have just been notified by the New York City DEP that because of a drought in the water supply, they are requesting that each person voluntarily decrease their amount of daily water consumption. Hold a family conference to decide how you will deal with this situation. Make a list of all of the changes you will make in your water use habits in order to follow the supplier's request.

5. When they have finished their lists of conservation techniques, encourage the groups to evaluate their usages once more with the next task:

   > It is now two months later. The water supplier has notified all customers that because of the concerning water shortage, each person is asked to limit their water use per day further. Make a list of the additional changes you will make in your water use habits in order to adhere to this new announcement.

6. When the groups are finished with their tasks, give each family an opportunity to share their conservation methods with the rest of the class. Since water conservation is important at all times and not primarily during drought conditions, take this time to discuss how the students felt about having to cut back on their water usage and why it is so important to do so at all times.

Variations:

- Encourage the groups to explore people's reactions to having to conserve water by performing skits of a family reacting to the water supplier's mandate. Include in these presentations the conservation methods the groups were able to come up with.

- Take a closer look at how the New York City Department of Environmental Protection actually does handle conditions such as these by researching NYC's permanent water conservation programs and drought regulations.

Watershed Discussion Questions

- If New York City's reservoirs are holding billions of gallons of water, why do city residents practice water conservation?
- List the techniques we may use in our homes to conserve the quantity of the water available to us.

Source: Adapted from *Drought Days Simulation* in The Official Captain Hydro Water Conservation Workbook

How Wet Is Your Home?
- A Home Water Use Survey

Grades: all grade levels
Objective: to encourage students to investigate how water is used in their homes
Subjects: Earth Science, Math, Social Studies

Materials: Copies of the *How Wet Is Your Home?* Survey

Information:

A dripping faucet or spigot can waste 20 gallons of water a day. That's 600 gallons a month. Enough water for 900 showers a year.

As we explore topics in water conservation and resource management, students cannot help but discover that even one person's actions can cause important reactions. This activity is a fun and informative follow-up lesson on the subject of water conservation because it encourages students to go back to their homes and take a closer look at their own water use routines.

The *How Wet Is Your Home?* survey guides students in an exploration of their home environment. The awareness that this exercise creates identifies many areas in which students can help to improve their own household's water usage.

Procedures:

1. After some activities and discussions on the subject of water conservation, give each student a copy of the *How Wet Is Your Home?* survey and the opportunity to bring it home and work on it there as a homework assignment.
2. The next day, when the class is back together, discuss the students' findings and the possible conservation-minded solutions they can think of to cut back on their water misuses.
3. If you wish to extend the lesson a bit further, encourage each student to commit to changing three water wasting routines in their home environment. Give them a copy of the *Ways To Save Water* information sheet and the time to work on these conservation projects with their families. After they have completed the task, encourage them to record their results on a new copy of the *How Wet Is Your Home?* survey or in the form of an artwork or writing exercise.

Variation:

- Encourage the students to explore the areas of your school that pertain to the questions on the survey. Then, after analyzing the school's efforts in water conservation, have the students propose ways in which the school might better use its water supplies. For more ideas related to this activity, see this section's *Class Follow-up Projects*.

Watershed Discussion Questions:

- From where does your home's water supply come?
- How much of that water supply did you calculate your household uses in one year?
- How much water would your household be saving using water conservation techniques?

How Wet Is Your Home?

Take this quiz and find out!

1. General Information About Your Home

What type of home do you have? ____house ____apartment ____mobile home ____other

How many people are living in your home? ____

What are the ages of the people living in your home? ____ ____ ____ ____ ____ ____ ____

What type of vegetation do you have outside of your home? ____________________________

If you have a dishwasher, how full do you usually load it? ____full ____1/2 full ____< 1/2

If you have a washing machine, how full do you load it? ___full ___1/2 full ___< 1/2

How many of each of the following do you have in your home?

____sinks ____showers ____bathtubs ____toilets ____outside spigots

How many showers are taken in your home in one week? ____ How many baths? ____

How many minutes is your family's average shower? ____

How many times is a toilet flushed in your home every day? ____

2. Your Home's Bathroom Water Uses

Shower (regular showerhead) 5 gals/min x ____ min/day x ____ days/week = ____

Toilet (Pre-1991 toilet) 5 gls (1.6 gls) x ____flushes/day x ____days/week = ____

Brushing Teeth (tap running) 2 gals/min x ____min/day x ____days/week = ____

Shaving (tap running) 2 gals/min x ____min/day x ____days/week = ____

Bath Tub (full tub) 36 gals x ____baths/day x ____days/week = ____

Subtotal .... = ____

3. Your Home's Kitchen Water Uses

Wash Dishes (tap running) 2 gals/min x ____min/day x ____days/week = ____

Dishwasher (full cycle = 16 gals or short cycle = 7 gals) x ____washes/week = ____

Subtotal .... = ____

4. Your Home's Other Water Uses

Laundry (full cycle = 60 gals or short cycle = 27 gals) x ____washes/week = ____

Car Wash (with hose) 10 gals/min x ____min/wash x ____wash/week = ____

Gardening (lawn watering) 10 gals/min x ____min/water x ____water/week = ____

Subtotal .... = ____

Total water used weekly in your home (add the subtotals) ...... = ____

Water used per person weekly in your home (Total / # of people) .... = ____

Ways To Save Water

Simple conservation tips for water uses at home

Looking for leaks

A dripping faucet can waste twenty or more gallons a day. A leaky toilet is hard to detect but it could be silently wasting thousands of gallons every year. An inexpensive washer from the hardware store is usually all you need to fix a leaky faucet, and toilet leaks can often be stopped by adjusting the float arm or plungerball. For information on detecting leaking toilets, see this chapter's *The Silent Water Waster* activity.

Washing up without wasting

With a regular showerhead, approximately 5 gallons of water are used for every minute of your family's showers. An easy way of conserving water without buying and installing a new showerhead is to either shorten your showering times or turn off the water while soaping up. As for the bath tub, put the stopper in the drain before running the water, then mix the cold and hot for the right temperature. Less water is wasted down the drain in this way. Also, filling the tub only part way saves many gallons of water.

Every minute adds up

For every minute that your tap runs, several gallons of water may be flowing by unused. That's why it is important to turn the water off while you are brushing your teeth, shaving or washing something whether it is your hands, vegetables or the dinner dishes. By keeping a bottle of drinking water in the refrigerator, you can also save the water wasted each time you run the tap waiting for the water to cool off.

Flushing it away

In 1992, New York city established a law mandating all new construction and renovations use the water-saving 1.6 gallons/flush toilets. The average older toilets use approximately 4 to 7 gallons of water with every flush. One way to save this water is to avoid using your toilet as an ashtray, wastebasket or garbage disposal. Other ways are to flush only when necessary and put a weighted plastic bottle in the tank of the toilet. A one gallon bottle will displace that much water and save your family a gallon of water with every flush.

Watching the automatic machines

Your dish and clothes washing machines use a lot of water for full loads. So, make sure that the machine is full before starting the cycle. If possible, when washing smaller loads of dishes or clothes, set the machine at the short cycle to conserve the water you will need.

Letting it run away

Excessive watering of lawns or inefficient washing of cars can waste a great deal of water out of the large spigot to the outside hose. Water the lawn slowly, thoroughly, and as infrequently as possible. Water at night to minimize the effects of evaporation from the sun. Lawns usually need only an inch of water each week. You can measure this by placing a can under the sprinkler while it is running. As for the car, wash it in sections, rinsing with short spurts from a hose with a nozzle that shuts off automatically. Try to wash the car near a lawn or shrubs to give them a free drink of the water running off of the car.

The Silent Water Waster

Grades: all grade levels
Objective: to demonstrate how to detect a leaking toilet system
Subjects: Earth Science, Chemistry, Math, Social Studies

Materials: A jar of food coloring, a toilet

Information:

A leaky toilet can waste up to 10,000 gallons of water in one year. That's enough water to take nearly two baths a day, every day, 365 days a year!

Believe it or not, one out of every five toilets leaks. How do you know when a toilet is leaking water? Toilet tanks usually don't leak water onto the floor. The undetected seepage from a leaking toilet flows down into the bowl and plumbing, silently wasting thousands of gallons of water a year. When a toilet is leaking, clean water in the tank slowly seeps into the toilet bowl. Because the water level in the toilet bowl must always stay at the same level, this clean water drains into the sewer pipes below. Therefore, this water is disappearing from the home without ever being used. The following test is a simple way in which students can detect a leaking toilet without calling a plumber.

Procedures:

1. After taking part in lessons and activities on the subject of water conservation, introduce the class to your school's plumbing system. This activity will take a closer look at how much water is used by the toilets of your building so take some time to review the parts and workings of your facility's toilet fixtures.
2. If at all possible in your school, locate a bathroom with a toilet that you and the students can test together. Begin by removing the lid to the tank of the toilet. Explain to the students that the water in the tank is the clean water that will replace the bowl water when the toilet is flushed.
3. Drop a little food coloring into the tank. Do not flush the toilet. If after ten minutes, color appears in the bowl, you have a leak that should be repaired immediately. Many leaks can be repaired without the help of a plumber. Your local home improvement center or hardware store should be able to help you.
4. As part of a home survey like *How Wet Is Your Home?*, encourage the students to perform this test on the toilets where they live.
5. Conclude the experiment with a discussion looking into the amount of water you would be able to save in fixing a leaking toilet and all of the other things that wasted water could be used for. As a way of quantifying the 10,000 gallons a year that a leaking bowl wastes, have the students calculate the amount of space that much water would take up if it were stored all in one place (See *How Big Is Big? Calculating Capacities*).

Watershed Discussion Questions:

- How many leaking toilets would drain the volume of the Neversink Reservoir (34 billion gallons) in one year?
- Where does water leaking from your toilet go to next?

Shower Timers

Grades: elementary
Objective: to enable the students to make their own water timer as a home water conservation tool
Subjects: Earth Science, Math, Social Studies

Materials: For each student: 1 ziplock sandwich baggie, a cup or glass, water, 1 large paper clip, 1 three foot piece of string, a ball point pen

Information:

The unfortunate thing about conserving water is that it often sounds much more difficult than it is. Explore, for example, the amount of water people generally use while taking a shower. According to the EPA's calculations on our average daily water consumptions, taking a shower with a regular showerhead uses approximately 5 gallons of water every minute. Therefore, for every minute we shorten our time in the shower, we are able to save 5 whole gallons of water. With a family of four each using 15 less gallons per shower per day, the amount of water saved can add up to 420 gallons a week and even an astounding 21,840 gallons a year!

The following activity will guide students through the process of making their own do-it-yourself shower water timer which they may then bring home to remind themselves and their families to take shorter showers to save water.

Procedures:

1. The following procedures can be done by most young students while watching your demonstration. The very young students may need assistance at times.

2. Begin with a discussion of the reasoning behind water conservation and a brainstorming session exploring ways in which students can conserve water in their own homes.

3. Explain to the class that they will be making timers that their families can use to limit their showering times to approximately three minutes. Demonstrate for the students how to make the shower timer in the following manner:

   A. For younger students: Pre-poke 4 holes into a corner of a baggie with a sharp ball point pen.
   For older students: Have them poke the 4 holes themselves.

   B. Make an S-shaped hook out of a large paper clip and poke it through both sides of the closed ziplock baggie about 3 centimeters from the side of the bag underneath the ziplock strip and diagonal to the bottom holes.

   C. Thread the string through the paper clip and tie the ends together making a loop to hang the shower baggie from the shower head.

D. Have the students measure down 9 centimeters from the top edge of the baggie and draw a line (or pre-draw the lines for the younger students). This is the fill line. Hold the baggie horizontally and fill it up to this line. Then let it hang diagonally from the paper clip until it nearly empties. It should take about 4 to 5 minutes for most of the water to leave the baggie. If it stops dripping, it is probably because the pressure of the water is low and the surface tension of the water prevents it from dripping out further.

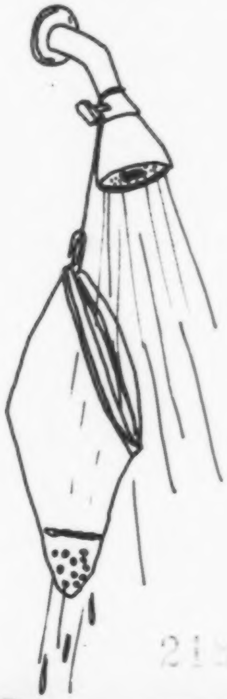
4. For the younger students: Demonstrate for the class how the shower timer works.
For the older students: Divide the class into small working groups. In each group, have the students fill up one of the baggies with the correct amount of water and time how long it takes for that amount of water to leak out of the baggie. The groups may then have to adjust the number of holes to make sure most of the water is gone after 5 minutes. Give the groups time to test all of their baggies and adjust them properly.

5. Discuss further with the class ways in which they can reduce the amount of water used in their bathrooms and throughout their homes.

Watershed Discussion Questions:

- If your shower head uses 5 gallons of water every minute, how much water would you use in 10 minutes? In 3 minutes?
- How much water would you save by shortening your showering time from 10 to 3 mins.?
- According the the 1990 U.S. Census, 7,332,548 people lived within New York City's limits at that time. If all of those people took 10 minute showers one day, how much water would they use all together? How much water would be used if each of them shorten their showers to 3 minutes?

Source: Adapted from *Shower Baggie* in All About Water: K-3 Water Activities



A Sharing Story

The view below made the sparrow sad.
As she flew high above the withering landscape,
her tiny shadow skimmed a parched African plain.
If not for the constant sun, she thought, the air would cool.
Plants could grow again. Animals could thrive.
Children could play in the rain.
But the sparrow was so small,
she was helpless against the unrelenting sun.

Or was she?

Suddenly, she had a thought.
She flew off and excitedly chirped her idea to
a wise old woodpecker who nodded in approval.
Being a sociable fellow, the woodpecker informed
a flock of pigeons, who scattered to tell others.
Soon the skies were abuzz with the sparrow's idea:
darters and snipes, hornbills and hawks, osprey and pelicans.
Even the crows were interested.
Only the vultures turned a cold wing to the plan.

The day arrived - bright and hot like all the others.
At the appointed hour, when the sun was at its height, the birds came.
From the east and west, from the north and south, they flew shoulder to wing.
They strained to fly as high as possible, circling in the mid-day heat.
Plants and animals looked up in disbelief.
The earth had suddenly cooled; the searing sun blocked
by the great clouds of birds soaring overhead.

Each day the birds returned. Day after day.
Protected from the scorching sun, the earth soon sprouted.
Animals frolicked and people found new hope.
Then, for reasons that the birds did not understand,
the sky began producing its own clouds. Soon, the rains came.

The sparrow looked down and smiled.
Her shadow was nowhere to be found.

- from *One Great Hour of Sharing*
The Reformed Church World Service, The Reformed Church in America

The Ways of the Watersheds

Stewardship Award

Grades: all grades

Objective: to encourage students to take an active part in the conservation of the quality and quantities of water

Subjects: Earth and Life Sciences, Social Studies, Chemistry, Health, Government

Materials: Copies of the *Stewardship of The Ways of the Watersheds* checklist

Information:

"There's a difference between interest and commitment. When you're interested in doing something, you do it only when circumstances permit. When you're committed to something, you accept no excuses, only results." - *Art Turock*

As we spend time exploring the topics involved in water and watersheds, students often discover that their own actions can make both subtle and dynamic differences. For it is through changes in our lifestyles that we will be able to conserve the qualities and quantities of our waters.

The following activity is a great project to use with students throughout their studies in water. This checklist is more of a guideline, leading students through their growth from curious learners to enthusiastic conservationists. The structure that this exercise follows identifies many areas through which students may learn more about water topics and work toward helping in the stewardship of the ways of the watersheds.

Procedures:

1. As the class learns more about the ways of the watersheds, introduce this program as an additional incentive for evaluating each of their own water-use lifestyles. In order to receive their *Stewardship of The Ways of the Watersheds Certificate*, each student must adopt at least two of the recommended water-sound practices from each of the categories on the application form checklist.
2. After completing this project, award each successful participate with their own personalized certificate. Obtain certificates by copying the enclosed award or writing The Frost Valley YMCA's Curriculum Specialist for official colored copies (there is an additional printing cost for each certificate plus postage) at 2000 Frost Valley Road, Claryville, NY 12725. So that we might know about and help with your school's work with the watersheds, please send copies of the completed applications to the Frost Valley's Curriculum Specialist.

Variation:

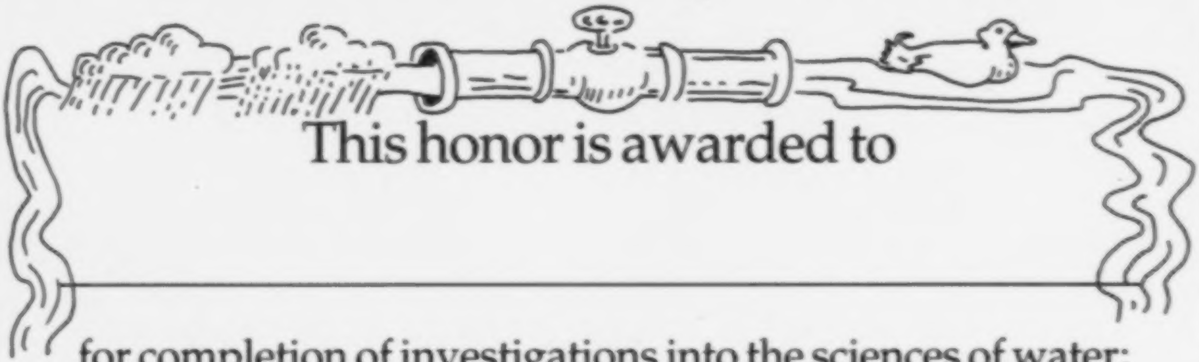
- Take on this project as a whole class achievement. Encourage the students to work together on all of the items so that the entire class receives the award for their efforts.

Watershed Discussion Questions:

- What watershed are your actions affecting every day?
- How can the efforts of one individual help to conserve a giant watershed?
- How does your community effect your area's watershed?

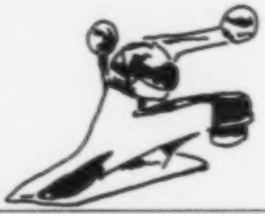
Ways of the Watersheds

Stewardship Award



This honor is awarded to

for completion of investigations into the sciences of water;
for projects conserving the quality & quantities of these resources;
and for the hard work and commitment shown through the
effort given on behalf of the ways of the watersheds.



> "Determine that the thing can
> and shall be done,
> and then we shall find the way."
> - *Abraham Lincoln*

School Teacher

School Principal

FROST VALLEY YMCA

The Ways of the Watersheds

Stewardship Award

Application Form

In order to receive the watershed stewardship award, you must complete at least two of the recommended water-sound practices from each of the categories listed below.

The Hydrology of the Watersheds

____ Take part in at least two activities included in this chapter of the Watershed Guide.
____ Draw an illustration of the water cycle.
____ Compose a musical piece that reflects your observations about water.
____ Write a poem about one aspect of the water in our world.
____ Write a story about the different stages of the water cycle.
____ Create an experiment that demonstrates one stage of the water cycle.
____ Create a water poster contest for your school.

The Geology of the Watersheds

____ Take part in at least two activities included in this chapter of the Watershed Guide.
____ Research the types of soils found in your area and start a rock collection.
____ Keep a journal of the different things you learn about water and soils.
____ Set up a composter for your home's table scraps.
____ Set up a composting system for your school's lunchroom scraps.
____ At school, have the soils tested for nutrient content and recommend soil enhancers to improve the quality of the soils without the use of chemicals.
____ At home, leave grass clippings on the lawn to recycle the nutrients.
____ In a garden, use trickle and/or drip irrigation to avoid erosion.
____ At home or school, install splashblocks under downspouts to prevent erosion.
____ Develop a student task force to seek out sites of water erosion in your community.
____ Reduce erosion along a stream, river or coastal beach with a planting program.

The Ecology of the Watersheds

____ Take part in at least three activities included in this chapter of the Watershed Guide.
____ At home or school, care for species of plants in a garden using organic methods.
____ At home or school, avoid chemical pesticides by encouraging birds and bats as natural predators of bothersome insects with nesting sites and wildlife habitats.
____ Study the ecology of an aquatic ecosystem.
____ Research one of your state's endangered species.
____ Take part in a school field trip exploring a subject in ecology.
____ In school, create a classroom aquarium containing different aquatic species from NY.
____ Participate in a stream or reservoir clean-up project.
____ Participate in an "Adopt-a-Waterbody" program sponsored by the New York State Department of Environmental Conservation.
____ Take part in a wildlife habitat improvement project.
____ Begin an environmental education program in your school or neighborhood.

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The Pollution Sources of the Watersheds

____ Take part in at least three activities included in this chapter of the Watershed Guide.
____ At home, select the least toxic approach to controlling pest problems.
____ At home or school, use mulches to prevent weed germination in the garden.
____ Conduct a household hazardous wastes audit of the products used in your home.
____ At home, investigate the use of less toxic cleaning solutions.
____ At school and home, recycle plastics, glass, metals and paper.
____ At home, save old household batteries and oil from your family's car for recycling.
____ Participate in a storm drain clean-up project.
____ Visit a site of on-going water pollution research in your area.
____ Organize a debate to discuss current water issues.
____ Paint a mural focusing people's attention to a water pollution concern.

The Development Within the Watersheds

____ Take part in at least two activities included in this chapter of the Watershed Guide.
____ Write a persuasive essay defending the opposite side of water issue you believe in.
____ Research the history of the development of your community.
____ Create a time capsule with contents representing you and your family's lifestyle. Bury the capsule or send it to a student in a community different from your own.
____ Write a pen pal letter to a student in a community different from your own.
____ Talk with your local historian.
____ Visit your local wastewater treatment plant.

The Technology of the Watersheds

____ Take part in at least two activities included in this chapter of the Watershed Guide.
____ Research the source of your community's drinking water supply.
____ Make a map of your watershed.
____ Locate any possible sources of pollution within your watershed.
____ Invite an employee of New York City DEP to your school.
____ Visit or learn about the reservoirs of New York City water supply system.
____ Learn about one of the Catskill watersheds by visiting the Frost Valley YMCA's Environmental Education Program, Weekend Family Programs or Summer Camp.

Conserving the Quantities of the Watersheds

____ Take part in at least three activities included in this chapter of the Watershed Guide.
____ Check for and fix all of the water leaks around your house.
____ At home, keep a container of water in the refrigerator so you do not have to let the water run in order to get a cold drink.
____ At home and school, place a plastic jug filled with water in the toilet tanks to reduce the amount of water flushed.
____ At home, clean your sidewalks, driveway, patio or deck with a broom instead of water.
____ Try to get by on as little water as possible during one week. Record your results.
____ Start taking shorter showers or filling your bath less.
____ Perform a water-use audit for your school.
____ Initiate a public awareness campaign educating students in your school about water conservation methods.
____ Start a YMCA Youth Earth Service Corp group in your school by working with your local YMCA. Contact the Frost Valley YMCA YESC Coordinator for more information.

YMCA Earth Service Corps

Learning to keep our earth fit for life

"I have a burning desire to both experience and contribute to the world . . ."
- *Adam, YESC Student*

"I think every student in all our schools was somehow affected by Earth Service Corps."
- *Paul, Earth Service Corps Teacher*

"The world will be saved by what we do, not by what we say."
- *Meredith, Earth Service Corps Student*

The YMCA Earth Service Corps Mission Statement

YMCA Earth Service Corps empowers young people to be effective, responsible global citizens by providing opportunities for environmental education and action, leadership development and international/cross cultural exchange.

Teens and YMCA Earth Service Corps

Earth Service Corps is an exciting way to make your community healthier, safer and better for everyone. Teens are too often perceived as problems for a community to solve. In YMCA Earth Service Corps, teens get positive, affirming challenges by being active members of their communities. Time after time, these students have successfully met that challenge and proven themselves as outstanding leaders.

The premise of Earth Service Corps is that students of today will largely determine the fitness of the earth to sustain life for the tomorrows to come. This program ties together environmental education, leadership development and student-organized service to their community and is based on a committed partnership between teens, teachers and schools and YMCA staff members. Earth Service Corps students learn about the nature of their local and global environments. Then, with the support from teachers and YMCA staff members, students make decisions, initiate projects and experience the thrill of making a difference.

Earth Service Corps is experiential learning

YMCA Earth Service Corps provides educational opportunities for high school students to encounter a wide range of perspectives on the environment. Through symposia, leadership retreats, field trips to natural settings and other activities, students develop their own values and attitudes about their environment.

YESC was initially organized in 1989 at a Seattle, Washington YMCA. Since then, it has developed into a nationwide program where students learn about leadership by organizing their peers and leading school-based environmental service clubs. Students work directly with YMCA staff members and teachers to plan and implement service projects, with much of the direction and initiative resting with the students.

Earth Service Corps students, teachers and staff members come from the inner city, suburbs and rural areas, from all races and backgrounds. They reflect the patchwork quilt of diversity that is our nation's greatest strength. Earth Service Corps projects are community-wide, involving businesses, churches, scientists, civic leaders, younger students and senior citizens. As a result, students learn that success depends upon their abilities to listen to and respect a wide variety of needs and perspectives. And it is their energy, idealism and capacity for positive action that are vital to the future of their local and global communities.

> "the idea, a spark
> the waiting students, a dry field
> the students' energy and ideas, a wind
> Earth Service Corps, a wildfire!"
>
> *- Aaron Greenmun, YESC Student*

Program information provided by:

New York's Regional and National YESC Resource Centers. For more information about Earth Service Corps programs in your area, contact:

YESC Northeast Regional Resource Center
The Frost Valley YMCA
Youth Earth Service Corps Program Coordinator
2000 Frost Valley Road, Claryville, NY 12725-9600
phone: (914) 985-2291, fax: (914) 985-0056

or

YESC National Resource Center
Metrocenter YMCA
909 Fourth Avenue, Seattle, WA 98104
phone: 800-733-YESC or (206) 382-5013
fax: (206) 382-7894

Making A Difference - Youth Action

Grades: middle and upper
Objective: to involve students in the protection of their local water resource
Subjects: Earth and Life Sciences, Chemistry, Health, Social Studies, Government

Information:

"One generation plants trees . . . another gets the shade." - *A Chinese Proverb*

We all need to protect our future resources, including our water supplies. As societies grow and develop, as the world becomes a more interconnected place, our futures will depend on each of our abilities to take intelligent and effective actions to insure the quality of our lives as well as those of the other people and future generations.

Water-stewardship group actions give students opportunities to exercise skills such as:

- organizing, processing and communicating accurate information;
- identifying and investigating issues, generating and testing hypotheses;
- taking and supporting positions persuasively;
- making appropriate decisions to identify and solve problems effectively;
- forming a set of standards and applying them to the evaluation of assumptions, sources, evidence, reasoning and arguments (critical thinking);
- evaluating beliefs, qualities and behaviors;
- understanding their rights and responsibilities as contributing citizens.

The following procedures outline the process by which an enthusiastic group of youths could initiate and implement a water-stewardship project of their own.

Procedures:

1. Begin by choosing an issue. First discuss its larger aspect such as water pollution and then narrow it down to a local issue. Identify a goal that you wish to accomplish. This can be a fairly general statement such as "reduce the amount of nonpoint source pollution from this school". List several projects that you may undertake to achieve this goal. Evaluate each of the possible projects to determine if you have the ability and resources to perform the task.
2. Next, determine exactly how to accomplish these goals. What strategies can you use? Strategies can be classified as Site-Specific, Local Government, Research, Documentation, Education or Information Actions. For additional ideas on these strategies and stewardship actions in each category, see *Stewardship of The Ways of the Watersheds*. Identify the audiences you will need to reach in order to carry out the strategy.
3. Plan the methods you will use to implement the action and reach the audiences you have identified. Organize your plans through specific statements (objectives). List the many tasks that must be done, who will do them and the timelines.
4. Make sure to take time to evaluate your project when it is completed. Document your progress and outcomes. Be sure to contact the Curriculum Specialist at the Frost Valley YMCA to record any successes and challenges your group may have had.

Source: Adapted from *Action Projects - Getting Started* in Participation in Government: Activities to supplement the mandatory Social Studies course in New York State schools

Stewardship of the Ways of the Watersheds

Strategies for youth group actions

> "I slept and dreamt that life was pleasure,
> I woke and saw that life was service,
> I served and discovered that service was pleasure."
> - *Rabin Dranath Tagore*

Water stewardship actions may take a variety of forms and purposes dependent upon the group's vision and targets. The following list is meant as a catalyst for brainstorming sessions for youth groups interested in working on projects in water conservation.

Site Specific Projects

- Take part in a water quality monitoring program.
- Clean up a designated waterway, i.e. a stream, river, beach, storm drain.
- Help prevent erosion by planting vegetation on banks, beaches or upland slopes.
- Monitor the condition of your local fire hydrants and stormdrains.
- Organize a litter clean-up program for your school grounds and neighborhood.

Local Government Projects

- Attend a county or city Water Quality Coordinating Meeting.
- Write your local representatives about your local water issues and concerns.
- Urge the appropriate agencies to enforce protective zoning or hazardous materials laws.
- Help establish a local park with a waterway view or access.
- Work with your community to develop a flood or drought contingency plan.
- Work with your community to develop a land use management plan.
- Visit your legislator's district office and tell her/him about your projects.

Science and Research Projects

- Conduct an opinion survey about water issues.
- Get to know your watershed.
- Review local and state laws pertaining to your watershed's structures and uses.
- Help with an on-going water research project, i.e. The Frost Valley YMCA/United States Geological Survey's Water Quality Research in the Catskills.

Documentation Projects

- Produce a water conservation video. Use it for groups and on local cable access.
- Review past copies of the local newspaper. Make a scrapbook of water-related events .
- Attend a watershed town meeting and report the results to your school or local newspaper.

Educational and Informational Projects

- Conduct a "Water Awareness Day" or "Clean Water Fair".
- Hold a clean water run, bicycle tour or swim-a-thon in which participants run, ride or swim the equivalent length of your water supply system.
- Organize a Household Hazardous Wastes Clean-up Day.
- Hold a community forum on water-related issues.
- Teach water resource issues to youth or adult organizations.
- Conduct a Water Tasting Contest to bring people's attention to water quality issues.

Conserving the Quantities of the Watersheds

Assessment Tools

Conservation Quandary

> "I have read many definitions of what is a conservationist,
> and written not a few myself, but I suspect that the best one is written,
> not with a pen, but with an axe. It is a matter of what a man thinks about while
> chopping, or while deciding what to chop. A conservationist is one who is humbly
> aware that with each stroke he is writing his signature on the face of his land.
> Signatures of course differ, whether written with axe or pen,
> and this is as it should be." - *Aldo Leopold*

Many of the activities in this chapter can be used as assessment tools themselves considering the techniques and formulas of the lessons. As students begin to identify their personal ideas and attitudes toward water conservation, bonus activities like the following can serve to deliver additional information plus help them feel confident about the quantities of water they would be able to save through simple conservation techniques.

Puzzle it out:

Can you solve this puzzler after reading the facts below? *Hint: Some of the facts simply provide information; others give clues to help you solve the puzzle.

- John takes one shower every day. His very messy son, Cody, takes a bath every night before he goes to bed. John's wife, Kathy, prefers to shower every other day. About how much water does this family use to keep themselves clean each year? How many families like this one would it take to use the water capacity of the Neversink Reservoir for bathing only?

Facts:
- Most Americans take one shower a day.
- The average person showers for 7.5 minutes.
- The average shower releases about 5 gallons of water every minute.
- About 66% of the water needed for a warm shower must be heated.
- People who take baths use about 36 gallons of water with each bath.
- The capacity of the Neversink Reservoir is approximately 34 billion gallons.

The Answers:
- This family uses 34,554 gallons of water each year to keep clean. At this rate, it would take 983,967 families one year to use the amount of water stored in the Neversink Reservoir. Luckily, the reservoir is constantly being replenished by its watershed.

Conserving the Quantities of the Watersheds

Class Follow-up Projects

How Wet Is Your School?

If after studying this section on water conservation the class is eager to build on these lessons, here are some ideas for successful follow-up activities on the subject of conserving the quantities of the watersheds.

Investigating how your school uses its waters:

- Armed with their knowledge and know-how of water conservation methods, encourage your students to investigate how your school uses its waters and explore possible water-saving techniques that can be implemented. Using the *How Wet Is Your Home?* survey as a reference, guide the class through inquiries into the school's facility identifying any water-wasting areas.

  Dripping faucets, for example, are known to waste thousands of gallons a year, but in a larger building with larger faucet openings, the water loss increases dramatically. At fifty pounds per square inch pressure, a dripping standard faucet opening is said to waste 15 gallons of water; a 1/32" opening leaks 180 gallons/day; a 1/16" opening leaks 714 gallons/day; a 1/8" opening leaks 2,850 gallons/day; and a 1/4" opening on a faucet can leak as much as 11,374 gallons in one day. Leaking or water-wasting models of toilets could also be draining thousands of gallons of the school's water every week.

"By learning you will teach; by teaching you will learn." - *Latin Proverb*

- After finding areas in which your school could decrease the amount of water that is wasted, encourage the students to make a report for the administrative and support staffs.
- Launch a public awareness campaign teaching the other students in the school not to waste water during their daily routines. For example, post flyers by the drinking fountains discouraging students from running the water too long while waiting for the right temperature. Or create posters for the bathroom sink areas instructing students how they can conserve water while washing their hands.
- Continue the public awareness campaign outside of the school by making artwork, newsletters or public service announcements teaching people how they can conserve water in the homes and businesses.

Appendix A

Common Organisms Found in Pond and Stream Habitats

These organisms are arranged in general categories under each of the three Kingdoms of *Monera, Plantae* (Plants) and *Animalia* (Animals). They are listed alphabetically within each category according to their common names. The Latin names are given alone for those organisms that do not have a generally used common name. This list is meant to be a starter list for first-time aquatic explorers. More comprehensive and quite lengthy lists may be found in many of the freshwater environment field guides.

Monera

Bacteria

- Actinomycetes (phylum)
- *Escherichia coli*
- *Leptothrix spp.*
- *Pseudomonas spp.*
- *Rhizobium spp.*

Plantae

Fungi

- Hyphomycetes (phylum)
- *Penicillium spp.*
- Water Mold, *Saprolegnia ferax*

Algae

- Diatoms, Bacillariophyta (phylum)
- Blue-Green Algae, Cyanophyta [often classified as Cyanobacteria]
- Golden Algae, Chrysophyta (phylum)
- Green Algae, Chlorophyta (phylum)
- Green Algae, Gamophyta (phylum)
- Dinoflagellates, Dinoflagellata (phylum)

Ferns

- Fairy Moss
- Ferns, Filicinophyta (phylum)
- Fern, Sensitive, *Onoclea sensibilis*
- Fern, Water, *Azolla spp.*

Mosses

- Hypnum, Water, *Hygrohypnum ochraceum*
- Moss, Peat, *Sphagnum*

Liverworts

Horsetails

Quillworts

Flowering Plants (*Angiosperms*) & Cone-bearing Plants (*Conifers*)

- American Lotus
- Bedstraw, Small, *Galium trifidum*
- Bladderwort, Common, *Utricularia vulgaris*
- Cattail, Broad-leaved, *Typha latifolia*
- Cattail, Narrow-leaved, *Typha angustifolia*

Angiosperms & Conifers continued

- Coltsfoot, *Tussilago farfara*
- Cowslip (Marsh Marigold) *Caltha palustris*
- Duckweed, Great, *Spirodela spp.*
- Grass, Canary *Phalaris arundinacea*
- Hornwort (Coontail) *Ceratophyllum demersum*
- Iris, *Iris spp.*
- Jewelweed, *Impatiens spp.*
- Lady's Slipper, Yellow, *Cypripedium calceolus*
- Pitcher Plant, *Sarracenia purpurea*
- Rushes, Juncaceae (family)
- Sedges, Cyperaceae (family)
- Skunk Cabbage, *Symplocarpus foetidus*
- Water Lily, White, *Nymphaea odorata*
- Water Parsnip, *Sium suave*

Trees and Shrubs

- Beech, American, *Fagus grandifolia*
- Cranberry, *Vaccinium spp.*
- Dogwood, Silky, *Cornus amomum*
- Maple, Red, *Acer rubrum*
- Oak, *Quercus spp.*
- Tamarack (Larch) *Larix laricina*
- Willow, Pussy, *Salix discolor*

Animalia

Invertebrates *(without backbones)*

Arthropods
(insects, crustaceans, spiders, mites)

- Backswimmers, Notonectidae (family)
- Beetles, Predaceous Diving, Dytiscidae (family)
- Beetle, Riffle (Water Penny), *Psephenus herricki*
- Beetle, Whirligig, *Dineutes spp.*
- Bug, Giant Water, *Belostoma spp.*
- Bugs (true), Hemiptera (order)
- Caddisflies, Trichoptera (order)
- Copepods, Copepoda (subclass)
- Crayfishes, Decapoda (order)
- Crustaceans, Crustacea (class)
- Damselflies, Zygoptera (suborder)
- Dobsonflies (Hellgrammite), Corydalidae (family)
- Dragonflies, Anisoptera (suborder)
- Fireflies, Lampyridae (family)
- Flies (true), Diptera (order)
- Flies, Crane, Tipulidae (family)
- Fly, Black, *Simulium venustum*
- Mayflies, Ephemeroptera (order)
- Mosquito, *Culex spp.*
- Scorpions, Arachnida (class)
- Scuds, Amphipoda (order)
- Spiders, Arachnida (order)
- Spider, Fish, *Dolomedes spp.*
- Springtails, Collembola (order)
- Stoneflies, Plecoptera (order)
- Water Boatmen, Corixidae (family)
- Water Fleas, Cladocera (order)
- Water Striders, Gerridae (family)

Mollusks

- Clams, Pelecypoda (class)
- Mussels, Freshwater, Pelecypoda (class)
- Slugs, Gastropoda (class)
- Snails, Gastropoda (class)

Protozoans (single-celled animals)

- *Amoeba spp.*
- *Paramecium spp.*

Sponges

Hydras and Jellyfishes

Rotifers

Bryozoans or Moss Animals

Worms

- Earthworms, Aquatic, Annelida (phylum)
- Flatworms, Platyhelminthes (phylum)
- Leeches, Annelida (phylum)
- Nematodes (Roundworms), Nematoda (phylum)

Tardigrades or Water Bears

Vertebrates *(with backbones)*

Amphibians, Amphibia (class)

- Bullfrog, *Rana catesbeiana*
- Frog, Green, *Rana clamitans*
- Frog, Leopard (Meadow), *Rana pipiens*
- Frog, Pickerel, *Rana palustris*
- Frog, Wood, *Rana sylvatica*
- Mudpuppy, *Necturus maculosus*
- Newt, Red-spotted (Red Eft), *Notopthalmus viridescens*
- Salamander, Two-lined, *Eurycea bislineata*
- Spring Peeper, *Hyla crucifer*
- Toad, American, *Bufo americanus*

Fish, Pisces (superclass)

- Bass, Largemouth, *Micropterus salmoides*
- Bluegill, *Lepomis macrochirus*
- Catfish (Brown Bullhead), *Ictalurus nebulosus*
- Minnows, Cyprinidae (family)
- Perch, Yellow, *Perca falvescens*
- Pike, Northern, *Esox lucius*
- Salmon, Atlantic, *Salmo salar*
- Shiner, Golden, *Notemigonus crysoleucas*
- Sunfishes, Centrarchidae (family)
- Trout, Brook, *Salvelinus fontinalis*
- Trout, Brown, *Salmo trutta*
- Trout, Rainbow, *Salmo gairdneri*
- Walleye, *Stizostedion vitreum*

Mammals, Mammalia (class)

- Bat, Little Brown, *Myotis lucifugus*
- Beaver, *Castor canadensis*
- Mink, *Mustela vison*
- Mole, Star-nosed, *Condylura cristata*
- Mouse, Meadow Jumping, *Zapus hudsonius*
- Mouse, White-footed, *Peromyscus leucopus*
- Muskrat, *Ondatra zibethicus*
- Opossum, *Didelphis marsupialis*
- Rabbit, Marsh, *Sylvilagus palustris*
- Raccoon, *Procyon lotor*
- Shrew, Water, *Sorex palustris*
- Vole, Red-backed, *Clethrionomys gapperi*

Reptiles, Reptilia (class)

- Snake, Common Garter, *Thamnophis sirtalis*
- Snake, Common Water, *Natrix sipedon*
- Turtle, Bog, *Clemmys muhlenbergii*
- Turtle, Eastern Painted, *Chrysemys picta*
- Turtle, Mud, *Kinosternon subrubrum*
- Turtle, Red-eared, *Chrysemys scripta elegans*
- Turtle, Snapping, *Chelydra serpentina*
- Turtle, Spotted, *Clemmys guttata*

Birds, Aves (class)

- Blackbird, Red-winged, *Agelaius phoeniceus*
- Coot, American, *Fulica americana*
- Cormorants, Phalacrocoracidae (family)
- Duck, Wood, *Aix sponsa*
- Eagle, Bald, *Haliaeetus leucocephalus*
- Flycatchers, Tyrannidae (family)
- Goose, Canada, *Branta canadensis*
- Grebes, Podicipedidae (family)
- Gull, Herring, *Larus argentatus*
- Harrier, Northern (Marsh Hawk), *Circus cyaneus*
- Hawk, Red-shouldered, *Buteo lineatus*
- Heron, Great Blue, *Ardea herodias*
- Kingbird, Eastern, *Tyrannus tyrannus*
- Kingfisher, Belted, *Ceryle alcyon*
- Loon, Common, *Gavia immer*
- Mallard, *Anas platyrhynchos*
- Merganser, Common, *Mergus merganser*
- Osprey, *Pandion haliaetus*
- Sandpiper, Spotted, *Actitis macularia*
- Sparrow, Swamp, *Melospiza georgiana*
- Swallows, Hirundinidae (family)
- Swans, Cygninae (subfamily)
- Thrushes, Turdidae (family)
- Vireos, Vireonidae (family)
- Warblers, Yellow-rumped, *Dendroica coronata*
- Waterthrush, Northern, *Seiurus motacilla*
- Waxwing, Cedar, *Bombycilla cedrorum*
- Wren, Marsh, *Cistothorus palustris*
- Yellowlegs, Lesser, *Tringa flavipes*

Appendix B

Local Water Contacts, Agencies and Stewardship Programs

The following is a listing of additional water contacts at local agencies that may assist you and your students in your exploration of the ways of the watersheds. For more information on support available through these trainings and programs, contact:

Teacher Trainings, Workshops and Student Programs

Frost Valley YMCA
The Ways of the Watersheds Curriculum
Curriculum Specialist
Frost Valley YMCA
2000 Frost Valley Road
Claryville, NY 12725
phone: (914) 985-2291

Central Park Conservancy
Water Monitoring Workshops
Jeffrey O'Handley, Science Ed. Specialist
The Arsenal, Central Park
New York, NY 10021
phone: (212) 315-0385

New York State DEC
Project Wild, Aquatic Wild
Susan Eshbach, Reginal Coordinator
Stony Kill Farm EE Center
Rte. 9D
Wappingers Falls, NY 12590
phone: (914) 831-8780

The Catskill Center for Conservation and Development
Streamwatch Programs
Tora Johnson, Program Director
Arkville, NY 12406
phone: (914) 586-2611

NYC Department of Environmental Protection
Bureau of Public Affairs, Community Services and Environmental Education
Kim Estes Fradis, Director of Education
59-17 Junction Blvd., 19th Floor, Corona, NY 11368, phone: (718) 595-3506

The Cornell Cooperative Extension
Water Monitoring and Related Water Resources, School Enrichment Progs., 4-H Projects
contact your local Extension Office or The Cornell Cooperative Extension of Sullivan Co.
attention: 4-H Program, 69 Ferndale-Loomis Road, Liberty, NY 12754
phone: (914) 292-4641

Student Stewardship Opportunities

Central Park Conservancy

Water Research Projects
(address listed above)

The Catskill Center

Student Stream Monitoring Projects
(address listed above)

NYS Department of Environmental Conservation, Division of Water

Water Stewardship Program
Public Participation Section
50 Wolf Road, Room 310
Albany, NY 12233-3501
phone: (518) 457-0669

Wetlands Programs
For Freshwater Wetlands
Natural Resource Office
contact your local DEC Regional Office

Citizen' Statewide Lake Assessment
Lakes Services Section
50 Wolf Road
Albany, NY 12233-3502
phone: (518) 457-7470

For Tidal Wetlands
Bureau of Marine Habitat Protection
DEC Region 1, Stoney Brook, NY
phone: (516) 751-7900

YMCA Earth Service Corps

Frost Valley YMCA
YESC Program Coordinator
phone: (914) 985-2291

Save Our Streams Program

Izaak Walton League of America
1401 Wilson Blvd., Level B
Arlington, VA 22209
phone: (703) 528-1818

River Watch Network

153 State Street
Montpelier, VT 05602
phone: (802) 223-3840

New York Sea Grant

Bob Linck, Extension Specialist
Cornell Cooperative Extension of Ulster Co.
74 John Street
Kingston, NY 12401
(914) 338-3494

Adopt-A-Stream

50 Salmon Creek Drive
Milton, NY 14468
phone: (716) 392-6450

The Audubon Soc. of NYS, Inc.

Lori Danuff McKean
P.O. Box 111
Eldred, NY 12732
phone: (914) 557-8025

Earth Team - USDA SCS

P.O. Box 7248
Syracuse, NY 13261-7248
phone: (315) 423-5521

Student Conservation Assoc.

P.O. Box 550
Charlestown, NH 03603
phone: (603) 543-1700

New York City's DEP - Stream Corridor Protection Program

Beth Reichheld, P.O. Box 370, Shokan, NY 12481, phone: (914) 657-5772

Cited Resources

Certain activities in this guide were adapted with permission from the following resources. Each of these curriculum guides are useful additions to educational libraries of teachers interested in teaching the subjects of water with experience-based, discovery-oriented lessons. To obtain current price listings and more information on these references, contact:

A Hidden Treasure: Instructional Materials for Groundwater Resource Protection
The National FFA Foundation
310 N. Midvale Blvd., Suite 308
P.O. Box 5117
Madison, WI 53705

Acid Rain: A Teacher's Guide, Activities for Grades 4 to 12
The National Wildlife Federation
141216th Street NW
Washington DC 20036

All About Water: K-3 Water Activities
Developed in cooperation with The DWR of California, The Metropolitan Water District of Southern CA, East Bay Municipal Utility District, Coachella Valley Water District, City of Fresno and Imperial Irrigation
The DWR Water Education Program
Anita Garcia-Fante, Chief
Publications Office, Room 338
P.O. Box 942836
Sacramento, CA 94236-0001

Beneath the Shell: A Teacher's Guide to Nonpoint Source Pollution and it's Potential Impact on New Jersey Shellfish
New Jersey DEPE
Office of Communications, CN 402
Trenton, NJ 08625-0402

Eco-Inquiry
by Cas Hogan
Institute of Ecosystems Studies
Box R
Millbrook, NY 12545

Ideas for Teaching About Runoff
New York State DEC, Bureau of Environmental Education
50 Wolf Road
Albany, NY 12233-4500

Golden Guide Pond Life
A Guide to Common Plants and Animals of North American Ponds and Lakes
by Reid, Zim and Fichter
Western Publishing Company, Inc., Racine, WI

Kid's Key to Catskill Creek Creatures:
A Dichotomous Key to the Invertebrates of Catskill Creeks
by Tora Johnson
The Catskill Center ERPF House
Route 28
Arkville, NY 12406

Land and Soil: Our Future Depends On It!
The Pennsylvania Alliance for Environmental Education
601 Orchid Place
Emmaus, PA 18049

Living in the Environment: Principles, Connections and Solutions
by G. Tyler Miller, Jr.
Wadsworth Publishing Company, Belmont, CA 94002
A Division of Wadsworth, Inc.

Living Lightly on the Planet:
A Global Environmental Education Curriculum Guide
Schlitz Audubon Center
Robert E. Nichols, Director
1111 East Brown Deer Road
Milwaukee, WI 53217

My World, My Water and Me: A Teacher's Guide to Water Pollution Control
edited by Ellen Gulbinsky & Maureen Bongiovanni
The Association of Environmental Authorities
233 Whitehorse-Mercerville Road, Suite 4
Mercerville, NJ 08619

Linking Your Y With The World
An Instructor's Guide for Global Environment and Development Education
by Kathleen M. Haskin
Revise, Recycle and Recover: Realizing Our Resources
by Claudia E. Swain
The Frost Valley YMCA
2000 Frost Valley Road
Claryville, NY 12725-9600

Participation in Government:
Activities to supplement the mandatory Social Studies course
in New York State schools
New York Education Department, The University of the State of New York
Publications Sales Desk, Room 171 EBA
Washington Ave
Albany, NY 12234

Pond and Brook: A Guide to Nature in Freshwater Environments
by Michael J. Caduto
University Press of New England
Hanover, NH 03755

Pond and Stream Safari: A Guide to the Ecology of Aquatic Invertebrates
by Karen Edelstein

Water Worlds
by Hawkes, Jirka, Krasny and Phillips
Cornell University Resource Center
7 Business and Technology Park
Ithaca, NY 14850

Scientific papers cited can be located with your library's reference section's journals such as:

Water, Air, and Soil Pollution
Water Resources Research
Ecological Applications
The Journal of Hydrology

Student Activity Sheets for Drinking Water Projects
item number: EPA810/F-92-003 July 1992
The United States EPA
Office of Water WH-550
Washington DC 20460

Taking the World to Camp: Creative Ideas for International Education at Camp
Winnipeg YMCA-YWCA
YMCA Canada
309-108 Argyle Avenue
Ottawa, Ontario K2P1B7

The Official Captain Hydro Water Conservation Workbook
East Bay Municipal Utility District
P.O. Box 24055
Oakland, CA 94623

The Story of Drinking Water: Teacher's Guide
by Rosalie Bock
American Water Works Association
6666 West Quincy Avenue
Denver, CO 80235

The American Water Resources Association Poster Series, Groundwater Poster
by Stephen Vandas, U.S. Geological Survey, Denver, CO
American Water Resources Association
5410 Grosvenor Lane, Suite 220
Bethesda, MD 20814-2192

Water Precious Water: A Collection of Elementary Water Activities
The AIMS Education Foundation
P.O. Box 8120
Fresno, CA 93747

Water Wisdom: A Curriculum for Grades Four Through Eight
available for purchase at: The Alameda County Office of Education
Carolie Sly, Curriculum Coordinator
313 W. Winton Avenue
Hayward, CA 94544-1198

NYC Supply & Watersheds Resources

A Guide to New York City's Reservoirs and Their Watersheds
Natural Resources Defense Council Publications
40 West 20th Street
New York, NY 10011

Beneath Pepacton Waters
written and published by Alice H. Jacobson, Andes, New York
Library of Congress Catalog Card Number 88-91455

Clearwaters
New York Water Pollution Control Association, Inc.
90 Presidential Plaza, Suite 122
Syracuse, NY 13202

Environmental Education Resources Teacher's Packet
The Magic School Bus At The Waterworks
Water is Valuable: New York WaterSaver's Workbook
NYC DEP, Office of Communications and Public Affairs
59-17 Junction Blvd., 19th Floor
Corona, NY 11368

The Legend of City Water:
Recommendations For Rescuing The New York City Water Supply
Hudson Riverkeeper Fund
P.O. Box 130
Garrison, NY 10524

Water Bulletin
New York State Department of Environmental Conservation, Division of Water
50 Wolf Road, Room 308
Albany, NY 12233-3502

Water-Watchers: A Citizens Guide to New York City Water Supply
Citizens Union Foundation, Inc. of the City of New York
198 Broadway
New York, NY 10038

Water: A Unified Science Supplement
The University of the State of New York, The State Education Department
Albany, NY 12234

Where to Find Information on Nonpoint Source Pollution in New York State
New York Nonpoint Source Coordinating Committee
c/o Bureau of Water Quality, NYS DEC
50 Wolf Road
Albany, NY 12233-3508

Additional Water Curricula and References

Each of these curriculum guides and informational references would be useful additions to educational libraries of teachers interested in teaching the subjects of water with experience-based, discovery-oriented lessons. To obtain current price listings and more information on these resources, contact:

Water Curricula

Activities for the Changing Earth System: Middle and High School Activities
The Ohio State University School of Natural Resources
2021 Coffey Road
Columbus, OH 43210

An Environmental Syllabus: Grades 10, 11, 12
The University of the State of New York
The Education Department
Bureau of General Education Curriculum Development
Albany, NY 12234

Aquatic Project Wild
for more information, contact your local NY DEC office
or Kyle Babbit-Myers
69 Ferndale-Loomis Road
Liberty, NY 12754

Clean Water Begins With Me!
Save Water Every Drop Counts:
A Water Conservation Activity Book for Teachers of Grades K-6
New Jersey Department of Environmental Protection and Energy
Environmental Education Unit
CN 402
Trenton, NJ 08625-0402

Groundwater: A Vital Resource: Student Activities
Organizing and Conducting a Cleanup on Public Lands and Waterways
Tennessee Valley Authority
Office of Natural Resources and Economic Development
Environmental/Energy Education Program
Knoxville, TN 37902

Learning to be Water Wise and Energy Efficient
Water Conservation and Energy Efficiency Program Student Activities
National Energy Foundation
5160 Wiley Post Way, Suite 200
Salt Lake City, UT 84116

Nature with Children of All Ages
Activities & Adventures for Exploring, Learning, & Enjoying the World Around Us
by Edith A. Sisson
The Massachusetts Audubon Society
Prentice Hall Press
15 Columbus Circle
New York, NY 10023

Outdoor Education Equipment: Plans For Easy-to-make Items
by Bachert Jr. and Snooks
The Interstate Printers & Publishers, Inc.
Danville, IL 61832

Pathways: Water in the Global Environment
by Waterstone
The National Council for Geographic Education
16-A Leonard Hall
Indiana University of Pennsylvania
Indiana, PA 15705

Take Pride in America with Mark Trail: A Coloring Book
The Mark Trail / Ed Dodd Foundation
c/o Lachee Nature Science Center
PO Box 2771
Gainesville, GA 30503

Teacher's Guide to World Resources
Comprehensive Coursework on the Global Environment
World Resources Institutes
1709 New York Avenue, NW
Washington DC 20006

Teaching Kids to Love the Earth
Sharing a Sense of Wonder . . . 186 Outdoor Activities for Parents & Other Teachers
by Herman, Passineau, Schimpf and Treuer
Pfeifer-Hamilton Publishers
1702 E. Jefferson Street
Duluth, MN 55812

Two H's and an O: A Teaching Resource Packet on Water Education
by Heimlich, Oberst and Spitler
Clearinghouse for Science, Mathematics, and Environmental Education
1929 Kenny Road
Columbus, OH 43210-1080

Water Activities Manual: Grades 6-8
Ventura County Water Conservation Program
Ventura County Resource Management Agency Planning Division
800 south Victoria Avenue
Ventura, CA 93009

Water Education: Grades K-6
by Daugs and Issraelsen
International Office for Water Education
Utah Water Research Laboratory
Utah State University
Logan, UT 84322-8200

Water Wise: Lessons in Water Resources
by Moran and Krasny
Department of Natural Resources
Fernow Hall
Cornell University
Ithaca, NY 14853-3001

Water: Can We Keep It Fit For Life?:
Problem-Solving Activities for Middle Level Science
New York Science, Technology and Society Education Project
89 Washington Avenue, Room 228
Albany, NY 12234

Water: We Can't Live Without It - Educator's Guide
The National Wildlife Federation
1412 Sixteenth Street NW
Washington DC 20036

Water References

The following references provide up-to-date information sheets and/or timely newsletters and periodicals on the subjects of water. All are valuable resources for an educator's library.

A Conceptual Framework for Water Education: An Educator's Guide to Goals, Concepts & General Objective for Curriculum Development
Water & Man, Inc.
220 South Second East
Salt Lake City, UT 84111

Church World Service Fact Sheets and Curricula
PO Box 968
Elkhart, IN 46515-0968

Concern, Inc. Community Action Guides
1794 Columbia Road, NW
Washington DC 20009

Access: Information on Global, International and Foreign Language Education
The American Forum for Global Education
45 John Street, Suite 908
New York, NY 10038

Perspective
The National Council for Geographic Education, Central Office
16A Leonard Hall
Indiana University of Pennsylvania
Indiana, PA 15705

New Jersey Water Watch Forum
New Jersey Department of Environmental Protection and Energy
CN 423
Trenton, NJ 08625

Rural Futures: New of Interest About Rural New York
NYS Legislative Commission on Rural Resources
Legislative Office Building
Albany, NY 12247

The Green Drummer: Sounding the Call of New York's Environmental Community
Greenworking
19 Marble Avenue
Pleasantville, NY 10570

The Small Flows Journal: A Collection of Professional Papers on the Study of Onsite and Small Community Wastewater Issues
The National Small Flows Clearinghouse

On Tap: Drinking Water News for America's Small Communities
The National Drinking Water Clearinghouse
West Virginia University
PO Box 6064
Morgantown, WV 26506-6064

The United States Geological Survey Water Information Resources
Ms. Margaret Phillips, Librarian
Rensselaer Technology Park
Troy, NY 12180

Water Compendia & Publications Listings

The following compendia and publication listings may be used to obtain current price listings and information on additional water curricula or references. Many of the listings are provided for little or no cost. The computerized compendia are current and comprehensive however they do require initiation and subscription fees.

Compendium of Educational Materials on the Water Environment for Macintosh Computers using Claris Filemaker Pro Software
Alliance for Environmental Education
PO Box 368, 51 Main Street
The Plains, VA 22171-0368

Catalog of Water Quality Educational Materials
Water Management Library, Tennessee Valley Authority
Haney Building 2C
1101 Market Street
Chattanooga, TN 37402-2801

Cornell Cooperative Extension Publications and Audio Visuals
Audio-Visual Center
7 Business & Technology Park
Cornell University
Ithaca, NY 14850

Directory of Great Lakes Education Material
International Joint Commission
PO Box 32869
Detroit, MI 48232

Environmental Education Compendium for Water Resources
The California Department of Education
Mathematics/Science/Environmental Education Unit
721 Capitol Mall, PO Box 944272
Sacramento, CA 94244-2720

4-H Natural Resources and Environmental Sciences Programs
Cornell Cooperative Extension
112 Fernow Hall
Cornell University
Ithaca, NY 14853

Marine Education: A Bibliography of Educational Materials
New York Sea Grant Institute
State University of New York and Cornell University
Dutchess Hall, SUNY at Stony Brook
Stony Brook, NY 11794-5001

National Drinking Water Clearinghouse for Small Communities
West Virginia University
PO Box 6064
Morgantown, WV 26506-6064

Sierra Club Sourcebook
Department J-203
PO Box 7959
San Francisco, CA 94120

SilverPlatter Information Compact Disc Data Storage
Educational Resources Information Center (ERIC)
Current Index to Journals in Education (CIJE)
Resources in Education (RIE)
SilverPlatter Information, Inc.
100 River Ridge Drive
Norwood, MA 02062-5043

The Ohio State University
ERIC Clearinghouse for Science, Mathematics and Environmental Education
ERIC/CSMEE Publication Catalog
1929 Kenny Road
Columbus, OH 43210-1080

The Overwhelmed Educator's Guide to Environmental Education
State Superintendent of Public Instruction
Old Capitol Building, PO Box 47200
Olympia, WA 98504-7200

The United States Environmental Protection Agency Publication Lists
Office of Wetlands, Oceans and Watersheds Publications (WH-556F)
Office of Drinking Water Publications (WH-550)
Catalog of Office of Science and Technology Publications (WH-551)
United States Environmental Protection Agency, Office of Water
Environmental Education Materials For Teachers and Young People (A-107)
United States Environmental Protection Agency
Office of Communication and Public Affairs
Washington DC 20460

Water Education Foundation Materials and Publications
717 K Street, Suite 517
Sacramento, CA 95814

Water Quality Educational Materials
Purdue University Cooperative Extension Service
Agricultural Communication Service, Media Distribution Center
301 S. 2nd Street
Lafayette, IN 47905-1092

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BODY

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2000 Frost Valley Road
Claryville, NY 12725-9600
Phone (914) 985-2291 Fax (914) 985-0056

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